PUBLIC WORKS

CITY COUNTY STATE

APRIL 16, 1921

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Short Span Highway Bridges

Urban, suburban and rural, Concrete, steel, wood and combination structures. Location, requirements, design, financing, construction and maintenance. Superstructures, substructures and architectural effect.

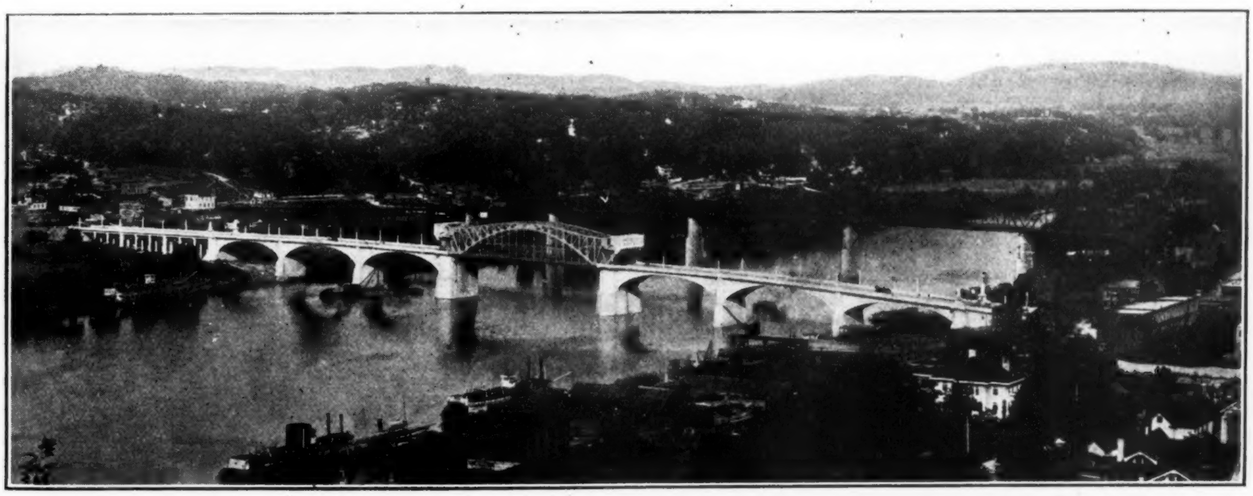
Long-span and lofty highway bridges are comparatively infrequent and are so costly that their design always warrants expert engineering and heavy outlay and generally requires construction that makes each bridge a special problem. They will therefore be excluded from present consideration, which will be limited to the vastly greater number of short-span bridges for vehicular, pedestrian and electric car service in city, town or country. These interest all state, county and municipal officials, are a vital factor in highway construction and maintenance, and involve an aggregate annual expenditure for construction, repairs and maintenance that is far in excess of that required for the long-span bridges.

PRIMARY CONSIDERATIONS

What type of bridge is best suited for a given case is dependent on whether it is to provide for urban, suburban or rural traffic, on existing traffic conditions, on length and height of span, on the character of foundations, on the location, and to some extent on commercial and labor conditions.

The widest, strongest, and therefore generally the most costly structures are imperative for urban traffic where there is likely to be little or no choice of location or elevation. In rural districts the bridges generally may and should be much lighter and cheaper, with few limitations of type or exact dimensions and often subject to considerable choice of position, thus giving a large freedom of design and proportionate opportunity for economy of construction. The corresponding features of suburban bridges are naturally intermediate between those of the urban and rural structures. Bridges on trunk lines and state highways, even though remote from towns, cannot be classified as rural structures, and must in general conform to many of the requirements for urban structures.

Urban and suburban bridges, those in parks and on boulevards and scenic highways, and all bridges in conspicuous positions (excepting possibly those in localities permanently devoted entirely to industrial and mechanical interests, such as those crossing railroad yards and heavy manufacturing districts) should be designed and con-



MARKET STREET BRIDGE OVER TENNESSEE RIVER AT CHATTANOOGA.
Steel bascule spans 300 feet long, multi-center concrete arch spans 165 and 180 feet long. Cost of superstructure $426,520, substructure $580,605. Completed December, 1917. B. H. Davis, Engineer.

structed with ample consideration for artistic and architectural effects; to harmonize with the surroundings, and to be consistent with the present conditions and future development of the locality, which they can often be made to adorn instead of disfigure. A bridge can sometimes be made monumental at little or no greater expense than is involved in building the most rigidly economical structure. These features are secured by proper attention to location, type, proportions, and details which, so far as possible, should be determined in conference with or be approved by competent specialists and critics.

LOCATION

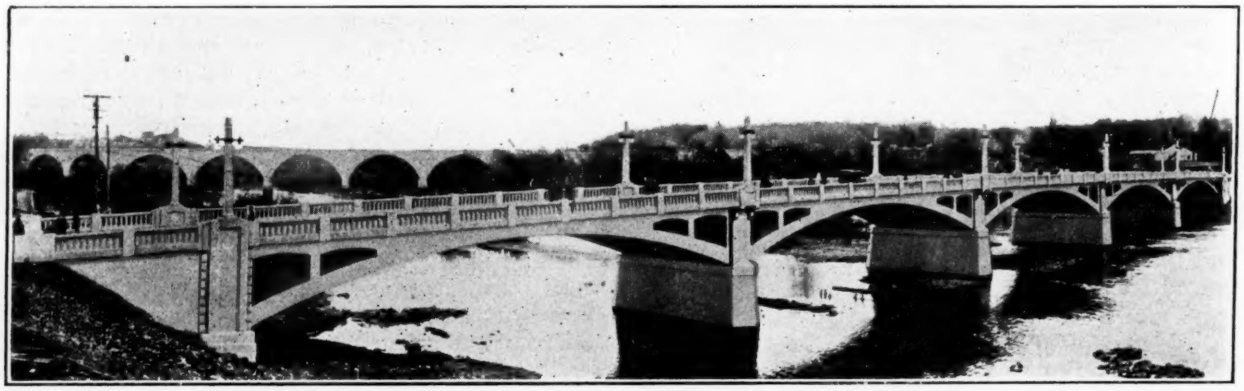
In cities and towns the location of a bridge is usually rigidly predetermined and can be varied only slightly, often at a heavy expense. In such structures there is therefore generally little choice in the length or position of the spans and not much in their elevation. In suburban districts there is likely to be some choice of position within given limits, often enough to materially modify the cost and design. For rural bridges there are much greater opportunities for freedom of location, which should be carefully exercised to secure the most advantageous sites, even sometimes at the expense of shifting the approaches to secure improved grade or alignment, better foundations, or shorter bridges, or to avoid dangers to or obstruction of navigation, or the condemnation of costly property.

In all cases the govening considerations should be safety, efficiency, ultimate economy, durability, and beauty. Rivers, especially those with much current, should be crossed at right angles and at sufficient heights for the superstructures to clear all possibility of flood and floating debris as well as to give necessary provision for navigation if there is any. Streets, highways, railroad tracks and canals should be crossed at right angles when convenient and with abundant vertical and horizontal clearance for all kinds of traffic under the bridge. In crossing over railroad tracks, recognition must be made of the possibility of wrecks on the railroad and the bridge should not be liable to destruction through their occurrence.

If the bridges are over navigable streams or harbors, consideration should be given to the possibility of future requirements for movable spans to permit shipping to pass and for the possibility of deepening the channel by dredging operations that may endanger foundations. The elevation of the floor should be kept as low as possible to avoid obstruction of and danger to highway traffic through heavy approach grades and the great cost of surmounting them by the traffic. Where there is a choice of location, care should be taken to secure a short structure with good foundations and on cheap land. The local requirements encountered are more likely to be easily complied with for new construction than for replacing old structures.

Where the structure connects low ground at either or both ends, it may often be advisable to supplement the bridge proper with a causeway, solid embankment, or earth fill between retaining walls, at one or both ends, thus materially reducing the length of the bridge and number of spans.

In replacing an existing bridge it is usually necessary to provide for traffic during construction. This sometimes involves building an entirely new temporary structure if the new spans are built exactly in the position of the old ones, or it may be that the old structure can be removed piecemeal while the new one is being erected in the same position and traffic maintained, or that the old structure may be removea and the new one built in successive longitudinal halves so that one half of either old or new structure is open to traffic while the other half is not. These considerations may sometimes make it desirable to deviate slightly from the old alignment and build the new structure close alongside the old one, retaining the latter in service until the new bridge is ready to receive traffic, after which the old one can be removed at leisure with a minimum of expense and interruption. Steel spans can sometimes be built complete at a nearby or remote position and rapidly moved to place over night or in a few hours while the old structure is being demolished or removed so that no temporary provision for traffic is required. Such operations are occasionally desirable for the safe construction of bridges over railroad tracks, particularly in freight yards and near terminals or over several main line tracks.



MONT CLARE BRIDGE OVER SCHUYLKILL RIVER, PHOENIXVILLE, PA.
Concrete arches, 103-foot span. Completed April, 1917. Superstructure cost $92,350, substructure $10,900. Rise 10 feet 6 inches.

LENGTH AND CAPACITY OF SPANS

Whatever the height or length of a bridge, its capacity depends on the width of roadway and the strength of span, which must be determined in accordance with traffic requirements. Broadly speaking, these vary according to the general classifications of urban, suburban and rural, but the character of the region, local condition, future probabilities and the type of roadway to be supported are of great importance, involving large variation in the service that the bridge is required to meet and therefore in its capacity and dimensions.

It is manifestly impossible to establish exact, arbitrary rules to govern any of these cases, but it is possible to follow standard practice and employ approved design and at the same time make adequate provision for strength and loading within certain limits. General requirements of strength, quality and workmanship should be written in the specifications, but these should be modified and details carefully determined by capable specialists whose function is to make the most advantageous selections or designs and to see that they are economically and reliably executed with justice both to the purchaser and the builder.

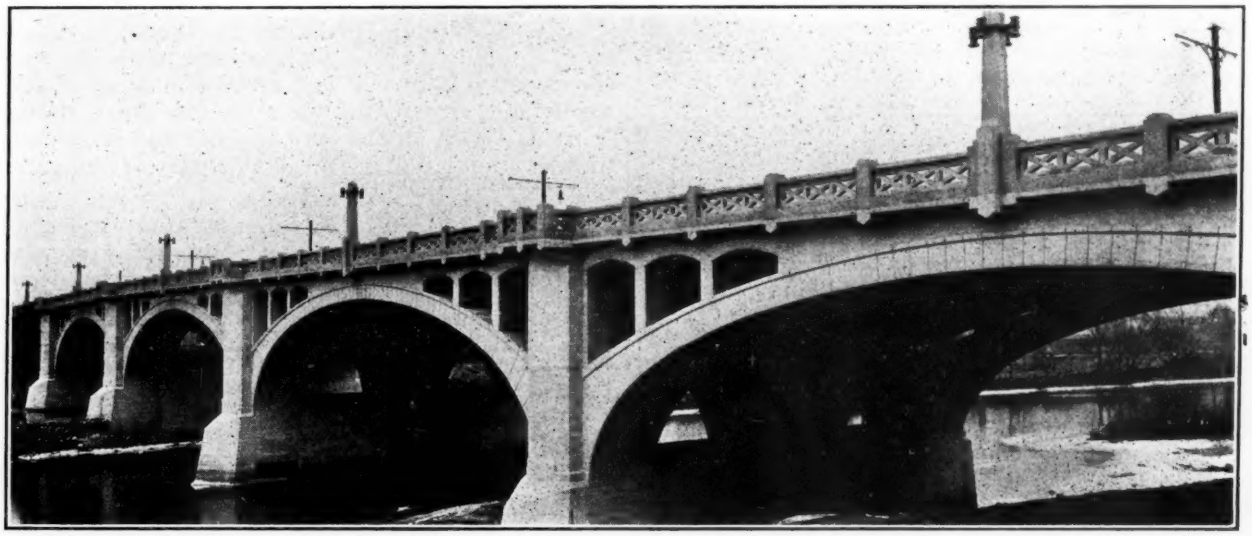
For cities and large towns the bridges should, if possible, be the full width of the street, of sufficient strength to carry any traffic or special loading that may travel the street, should carry the pavement continuously across the structure and, when practicable, the structures, excepting protecting parapets, should be built entirely below road level. They should be proportioned for the heaviest concentrated team loads, for the transportation of heavy machinery or equipment, and for the entire floor surface to be covered with vehicles or solid crowds of pedestrians, with ample provisions for wind strain, impact, vibration, irregularity and deterioration. The style should be plain, dignified or even severe.

Suburban bridges may be narrower and, according to their proximity to great cities, heavy manufacturing centers or industrial highways may provide for the same or decreased loadings required for city bridges. Especial care should be taken to design them so that their type may be harmonious with the local surroundings, general landscape and future improvements.

Practically the same considerations apply to bridges on boulevards and hard state highways and trunk lines, except that in some cases no provision may be necessary for future electric car service and in other cases statutory restrictions of traffic on the roadway may exclude heavy trucking, which therefore need not be provided for. On the other hand, they may serve very rapid or congested pleasure or tourist traffic requiring wide roadways and provision for higher speed than is permissible within city limits. Both of them are factors that influence the type and details developed.

In strictly rural localities much greater latitude is permissible than elsewhere, and under some conditions the width and capacity of the structure may be much less than in city and suburban localities. They should always, however, be wide enough to give clearance for, and strong enough to carry, two heavy automobile trucks or a full load of moderate weight automobiles going in the same direction at moderate speed. In all localities, spans of 50 feet or less should be proportioned to have their floor surface entirely covered with heavy, fast moving vehicles.

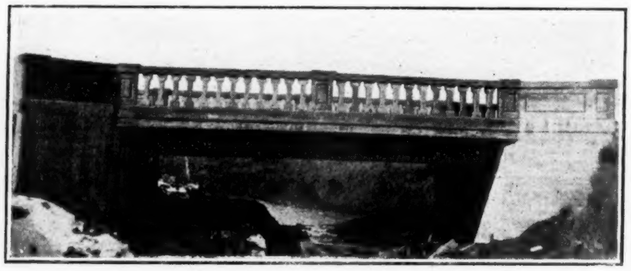
In all cases the floor itself should be proportioned throughout for maximum loads and impact, and the roadway should be thoroughly protected by substantial barriers on both sides that will prevent the possibility of vehicles leaving the bridge except at the ends. The bridge floor should be crowned slightly toward the center of the span or group of spans, or should be level, or on the lowest possible uniform grade, and the utmost efforts should be taken to avoid a descending grade on the approach toward either end ot the bridge, as such is likely to cause dangerous impact on the bridge floor.



PENN STREET BRIDGE OVER SCHUYLKILL RIVER, READING, PA.
Five 110-foot and nine 48-foot concrete arch spans. Completed November, 1913. Cost $437,470. B. H. Davis, engineer.

SUB-STRUCTURE

The design and location of the sub-structure (piers and abutments) is inseparable from that of the superstructure (the connecting spans), inasmuch as the distance between supports is a vital factor of the cost of the superstructure and the safety and durability of the structure is primarily dependent on that of the sub-structure. However, the type and method of construction of the sub-structure may be almost or quite independent of the superstructure. It has long been accepted almost as axiomatic that the most economical bridge is, roughly speaking, one in which the cost of the superstructure is about equal to that of the sub-structure, so that the higher the span and the more difficult the foundations the greater should be the distance between the piers; and conversely, for bridges with a comparatively low elevation where the water is shallow and the foundations are good, the spans should be made very short. These conditions are obviously influenced by circumstances of flow, navigation and railroad traffic and other special features that may exist under the bridge.



28-FOOT GIRDER SPAN, 24-FOOT ROADWAY

It should, however, be remembered that, other things being equal, the cost of spans increases approximately with the square of their length and that the cost of river foundations increases rapidly with the depth of the water. Also that the cost of the superstructure can be closely predetermined while that of the sub-structure is often very uncertain and may involve very large unexpected items and operations of a slow and dangerous character that are not foreseen in advance.

When, therefore, it is a matter of choice and conditions are uncertain, it is safest to reduce the number of foundations at some addition to the minimum cost of the bridge. This is especially true in regard to bridges over streams where the obstruction of the flow by channel piers may produce changed conditions that will impound the water, flood adjacent territory, scour the river bed or obstruct the channel so as to cause accumulation of drift and ice and in various ways produce serious damage.

EXPLORATIONS AND METHODS

Unless there is available complete, reliable knowledge of the river bottom, the expenditure of considerable time and money for careful exploration, surveys and soundings and sometimes tests by experienced specialists is well justified and determination of the character and location of piers and abutments should be based on such information. The most desirable sub-structures are solid concrete or stone masonry carried down to bed rock or hard stratum. If this is impracticable, they may be supported on pile footings or may have their bases extended so as to reduce the unit pressure and prevent settlement. In all cases they should be carried below the possibility of displacement or interference by flood or other disturbances or should be completely protected against them. Excavation to a depth of 5 or 6 feet below water level can easily be made in the dry by simple cofferdams kept dry by pumping. Unless the bottom is very irregular rock and boulders or quicksand, the same can usually be done up to a depth of 15 or 20 feet or in some cases to an even greater depth by the use of more costly cofferdams and pumping, thus enabling the sub-structure to be built as on dry land. For greater depths, or for very difficult bottom, access can generally be had only with very expensive pneumatic caissons.

If the bottom is strewn with boulders it is likely to be hard and strong enough for short-span piers, and may generally be cleared by dragging, scraping or by divers, sufficiently to permit the construction of a cofferdam there; or if the depth and velocity of water is too great, a log crib filled with stones may be sunk and concreted for the foundation of the upper part of the pier.

FOUNDATIONS

Soft bottom can often be excavated by dredging, and piles be driven and cut off by a submerged circular saw and thus made ready to receive pier footings built in cofferdams that are not pumped out until after a few feet of concrete has been deposited on the pile tops to seal the bottoms of the cofferdams.

In other cases, the lower parts of the piers can be built in floating caissons or cofferdams with detachable bottoms that are towed to position, sunk to rest on the pile tops, and the piers completed, after which the sides of the cofferdams are removed, leaving the piers supported on the bottoms of the caissons interposed between them and the pile tops. In such cases the caissons can be made with either wooden or concrete bottoms, the latter thus being made integral with the pier shaft if necessary. Sometimes clusters of wooden piles are driven in thin steel cylinders that have been sunk a short distance below the river bed and are subsequently filled with concrete. Groups of concrete piles with their tops extending above water level are sometimes used for the foundations of piers or for light work; these piles are sometimes continued up to form the pier as well, and constitute the sole support of short spans.

(*To Be Continued*)

Winter Work for the Street Force

The Street Division of Waltham, Mass., last winter managed to find a number of jobs to do that were worth while. A street that had been graded to sub-grade was covered with gravel, to be compacted by traffic and leveled off and surfaced in the spring. Sand to be used in connection with oiling roads was dumped in piles along the roads where it would be needed. Grading and widening two or three roads was carried on. At

the city quarry rock was got out ready for crushing, about 200 tons during February alone, and the crushing machinery was put in order. The steam road rollers were thoroughly overhauled and extensive repairs made. Paper on the refuse dumps was baled and stored at the city stables until better prices were obtainable, twenty or more tons being baled.

Complete Road Plant in Iowa

Camp and central mixing plant midway of a five-mile contract. Unusually complete plant. Long haul of concrete not objectionable.

A description of an unusually complete contractor's plant for road construction is given by the Service Bulletin of the Iowa State Highway Commission. This is the plant of the Horst Construction Co., built in connection with the construction of a 5.14 mile concrete road in Cerro Gordo County.

J. W. Horst, of that company, located a construction camp about midway of the contract, carefully designing and staking out a camp site including a mixer and material bins, stiff-leg derrick, cement sheds, garage and office. A standard railway track was laid from a near-by railroad to the plant and an industrial railway track for hauling cement from the sheds to the mixer. The contract was awarded on March 17, 1920, and a camp was under way before the frost was out of the ground.

At this camp was located a central mixing plant, this being the first road construction from a central plant tried out in Iowa. The mixer was placed on concrete foundations, and a concrete pavement was laid where the trucks were to stand for receiving the concrete from the mixer and the space around it was carefully drained and graveled. A good roadway was built leading from the mixer to the highway and in addition the public highway was graveled for the stretch to be used by the contractor's truck. The mixer structure was so arranged that canvas could be spread to protect the men and machinery from sun and rain.

The outfit for this job included 15 one-ton Ford trucks with dump bodies and 2 with general service bodies, a Lakewood finishing machine, a Koehring concrete mixer, a Buffalo stiff-leg derrick with one-cubic-yard clam-sheel bucket, 18 ten-foot sections of Blaw-Knox road forms with pins and wedges, 3 Domestic force pumps, 11,940 feet of two-inch black-iron pipe with expansion joints for every 1,500 feet and unions for every 800 feet and T's for every 150 feet, an auto truck turntable, a 1,000-foot railroad siding and an elevated industrial railway track from cement shed to mixer.

Thirty men were employed at the plant, 3 working between the railroad cars and the cement shed and the industrial cars to the mixer station, 2 handling cement from the industrial cars to the mixer platform, 2 charging the mixer, 1 mixer operator, 1 derrick operator and a helper, a chief mechanic in garage and 2 helpers, 2 turn-table men, 3 concrete spreaders, 2 men on finishing, 2 form setters, 4 subgraders with a team, 1 horse for hauling cement, and 3 men covering and wetting concrete.

From the start the work was organized and run on a regular schedule, trucks arriving at the plant and departing on the minute. Every truck in going to the mixer passed the garage where the master mechanic immediately took out of service any which was crippled or needed attention of any kind and a reserve truck was substituted in its place. At night all 15 trucks were lined up in front of the garage and given an inspection and prepared for service the following morning.

At the road where the concrete was to be deposited was a portable turntable which was dragged ahead from time to time so as to be kept a short distance ahead of the construction. The loaded truck ran up on the turntable, was turned in a few seconds by two boys, backed the few feet required and dumped its load and returned; all this without the delay and cutting up of the subgrade which absence of the turntable would have made necessary.

The longest haul was about three miles. It was found that by carefully noting the length of haul and the moisture condition of the sand and gravel and varying the amount of mixing water to suit both conditions as well as the atmospheric condition, the wet concrete mix could be delivered on the subgrade at the laying point in even and uniform condition, capable of passing every test and meeting all requirements. There was little or no trouble on even the longest hauls with a separating of the materials, nor in initial setting of the mixed material before it was placed. The average length of time a load of mix was on the road on the longest haul was approximately 15 minutes. Probably not more than half a dozen loads of mix were lost on the entire work because of delay in delivery occasioned by accident to the truck or otherwise.

During the few minutes of transportation the mixed concrete absorbed the water more thoroughly and appeared somewhat stiffer when spread than does that from a mixer on the spot, but there was no special difficulty in working and shaping it with template or tamping devices or finishing machine. Belting was a little more difficult because less water came to the surface and the surface material was more sticky and the belt had a tendency to drag small stone to the surface. Such stones were picked out and additional belting restored the workability of the surface and removed all traces of holes. Some engineers who inspected the work thought the central mixed concrete worked up better in the end than the locally mixed type, some thought the reverse and most engineers could see no difference.

The central mixing plant was especially well adapted to this particular job as there were numerous curves and narrow places in the right-of-way and cuts which would have interfered seriously with the use of an industrial railway had this been used for bringing the aggregate materials or hauling the dry mix.

This contract comprised 21,060 cubic yards of excavation at $1.31 and 54,435 square yards of concrete surface at $3.74, a total of about $231,000. The concrete was 8 inches thick at the center and

7 inches at the edges and the roadway was 18 feet wide.

The average daily run ($10\frac{1}{2}$ hours work), in spite of almost daily shortage of materials, was 365 lineal feet or 730 square yards. The maximum daily run was 600 lineal feet earning for the contractor $4,488. The day's work was ten and one-half hours.

Making Narrow Roads Wider

By John Stanley Crandell*

Adding a shoulder of bituminous macadam on each side of a narrow concrete road. Details of construction method.

There is a very large mileage of narrow hard-surface highways that have become inadequate through changing traffic conditions. Many of these roads are requiring excessive maintenance. Others have not yet shown the effects of the increasing traffic.

Various schemes have been tried to widen these roads without undue expense. Of them all, the plan to extend the width by building bituminous macadam shoulders has been the most widely used, and gives the most promise. In addition to the large mileage already built, many roads have been planned, or are under construction, that will eventually have to be widened. Provision should be made in the design of all new roads to take care of constantly increasing traffic of the future, and to that end, shoulders should be built at the time of construction.

Much progress has been made in highway design, construction and drainage, but the question of shoulders has been overlooked. Many costly highways still are constructed with earth, gravel or water-bound macadam shoulders, which are inadequate for present-day motor truck traffic. Shoulders of these types are rapidly worn out or destroyed, and thus become sources of danger, imperiling the life of the motorist who turns out to let another vehicle pass.

Nine-foot roads can be widened to any desired measurement by building shoulders on each side. The 9-foot road then, being in the center, takes most of the traffic; whereas, if another 9-foot strip be built alongside the original construction, traffic will straddle the old and the new with consequent unpleasant riding. In many localities the existing 18-foot roads are being found inadequate, and they are being widened to 24 feet by building 3-foot shoulders on each side. Six-foot shoulders also have been tried with success; in fact, a 6-foot shoulder is easier to build than one of lesser width.

There are certain practical factors that must be taken into account when this work is attempted. In the first place, the depth of the new shoulder must not be slighted. Eight inches is the minimum that should be allowed, for it must be remembered that these shoulders will have to take heavy loads, and that they will not be an integral part of the original road and thus will receive no support from it.

Gravel or water-bound macadam shoulders may be turned to good account by using them as foundations on which to place a bituminous macadam wearing course. It is good practice to build water-bound macadam shoulders when the highway is being constructed, with the idea in mind that at the end of the first year the shoulders will be topped with bituminous macadam.

The following paragraphs describe the best standard practice of laying tar macadam shoulders in widening old roads:

A trench for the new shoulder must be dug alongside the pavement, and no more earth should be taken out than may be necessary. It is sometimes difficult to roll the bottom of the trench uniformly, and therefore it is important **not to disturb the sub-base.** Any soft spots must be replaced with new earth, after making sure that these places, and any others that need it, have been properly drained. The berm adjacent to the shoulder should be leveled off so as to insure all surface water finding its way into the side ditches.

If possible the earth base should be rolled, and for this purpose a light tandem roller is best. If a 3-wheel roller is the only one available, then the rolling must be done with one rear wheel, unless a very wide shoulder is being built. Care must be taken during this rolling to see that the edge of the pavement is not chipped or broken.

Six inches of stone (stone that will pass a $3\frac{1}{2}$-inch ring and be retained on a $2\frac{1}{2}$-inch ring) is then deposited on the earth base and rolled to $5\frac{1}{2}$ inches in depth. This forms the foundation for the shoulder. The voids are filled with sand or screenings, and the foundation is rolled until it resembles a water-bound macadam, additional filler being added from time to time, if required.

A tar-macadam wearing course is then constructed by placing a 3-inch layer of tough, hard 2-inch stone on the foundation. This is rolled to $2\frac{1}{2}$ inches in depth, and then hot Tarvia-X is applied at the rate of 1.7 gallons per square yard. Where the job is not of great extent, hand pouring pots may be used, and the Tarvia may be heated in kettles on the job. But if there is considerable yardage it will be found more economical to apply the binder from tank wagons or from motor truck distributors. The wearing course should be prepared a long distance ahead, since the spraying of Tarvia, either from tank wagon or distributor, is done rapidly and this part of the work should not be delayed.

The first coat of Tarvia-X is covered with $\frac{3}{4}$-inch stone chips, which are rolled into the voids of the wearing course. Those chips not held by the binder are swept off, and a second, or seal coat of Tarvia-X is applied at the rate of $\frac{3}{4}$ gallon per square yard. This is covered with pea-gravel, or stone chips, and the shoulder is

*Consulting Engineer, General Tarvia Dept., The Barrett Company.

well rolled. When the seal coat is being applied, see to it that an extra quantity of Tarvia is introduced along the joint to insure its being absolutely waterproof. If water finds its way in here the sub-grade will be softened and the shoulder may be depressed at that place.

Maintenance of all shoulder work is absolutely essential if good results are expected. Shoulders are subjected to exceptionally heavy thrusts from laden motor trucks running at high speed, and they must be kept in first-class condition throughout the year if they are to give the service desired. Holes that may form should be patched as soon as they appear, and the entire shoulder should be given an occasional treatment with Tarvia-B.

In the case of new roads, the work of constructing shoulders is simplified, since the subgrade for the shoulders can be graded and rolled at the time this work is being done for the pavement itself.

Pre-Cast Concrete Slab Pavement

About half a mile of a new type of concrete highway pavement was built last winter by the Wyoming State Highway Department to carry very heavy oil-field traffic over the gumbo flats and sandy stretches between Casper and Salt Creek.

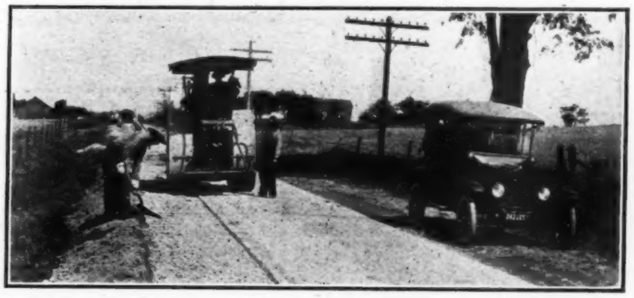
In 1917 the State Highway Department and the Mid-West Oil Company united in grading and draining a 39-mile section of the road and during 1919 paved 5 miles with concrete 16 feet wide. This road has been subjected to a heavy traffic estimated at 10,000,000 pounds per month besides a hundred additional motor vehicles daily that require a high-class hard-surface roadway.

To concrete the road in situ in the usual manner with a traveling concrete mixer would have involved great expense and difficulty in the delivery of materials because there was no supply of aggregate except at one point and it would have been necessary to install an expensive water supply plant. It was therefore determined to built an experimental length of 24,000 feet of the roadway with pre-cast slabs manufactured in a yard at Casper, at one end of the road adjacent to the supply of aggregate and water.

The State Highway Department designed 8 x 9-foot slabs 6 inches thick reinforced with wire mesh and ½-inch bars, which were made and laid by the Levy Construction Company, Denver. The slabs were made in six equal lots, each of them having a different type of joint, some of which were straight, some beveled, some curved and some interlocked and bolted together. The work was not commenced until late in the season, and was continued into very cold weather when the mercury went far below freezing, much increasing the cost of preparing the sub-grade and making it necessary to heat the aggregate and mixing water.

The slabs were delivered from the yard to the site by State Highway trucks at a cost of 39 cents per ton-mile. They were loaded and unloaded by 3-ton triplex chain hoists suspended from trolleys on traveling gantries that spanned

TRENCH AND BASE STONE FOR SHOULDERS



FILLING AND ROLLING BASE COURSE

POURING PENETRATION COURSE AND APPLYING KEY STONE

ROAD WITH SHOULDERS COMPLETED
Trench excavated 7½ in. deep and 4 ft. wide. Base stone placed 5 in. thick and 4 ft. wide. Wearing course 2½ in. thick and 3.5 ft. wide. Finished surface 16 ft. wide.
SHOULDER 3.5 FEET WIDE ON EACH SIDE OF A 9-FOOT CONCRETE ROAD; FOUR MILES NORTH OF KAUKAUNA, WISCONSIN.

the road. They were laid with one 8-foot side coincident with the center line of the roadway, thus forming a continuous strip of pavement 9 feet wide that could be duplicated by slabs on the other side center line, making up the full width of 18 feet. Up to the present time the pavement shows no deterioration under heavy traffic and the best type of joint has not been determined, although the interlocked type is considered least desirable.

Engineering Costs on Montana Roads

The second biennial report of the Montana State Highway Commission gives among many other interesting data, the cost of pre-construction engineering and of construction engineering, both total and as percentages of the construction cost. Pre-construction costs include reconnaissance or investigation, preliminary and location survey, plans and specifications, advertising for bids, contract letting, and miscellaneous.

For all contracts let to date, totaling 661.44 miles and $6,222,689, the pre-construction charges average 1.84 per cent of the contract price. Surveys are made for some projects that are never carried out, but the cost of these to date has been less than 0.3 per cent of the total construction costs to date.

Construction engineering charges to date have averaged 6.46 per cent on grading and gravel roads, 3.53 per cent on paved roads, 4.61 per cent on bridges; or 5.58 per cent average of all road and bridge projects.

Federal Aid Road Work

By Thos. H. MacDonald*

Federal aid to the extent of $216,000,000 paid or obligated, leaving only $50,-750,000 unobligated. Road construction has not kept pace with traffic increase. Heavy construction this year will be followed by a decided reaction next unless Congress makes another appropriation for Federal aid.

Except in a few states, Federal aid funds for road building will be practically exhausted at the end of the present calendar year. On the first of January, 1921, of the $266,750,000 of Federal funds allotted to states, there was either paid on completed work or obligated by approved projects approximately $216,000,000, leaving approximately $50,750,000 unobligated. On that date $149,-683,107 of Federal aid was either actually under construction or completed, leaving $117,066,893 available for new contracts. This last amount has since been reduced so that at present but little more than $100,000,000 is available for new contracts and this amount did not become available until last July. Considering that after funds become available some time is needed for making surveys and plans, advertising for construction and letting contracts this record seems very good.

The total amount paid or due states on March 1, 1921, for work actually completed was $89,337,-889. On that date there had actually been paid out of the United States treasury $62,867,284, so there was then due the states $26,470,605. There is a lag between the completion of construction work and the actual disbursements from the treasury due to the fact that many of the state have been carrying the cost of the projects which are under way until they are nearly or entirely completed.

The total mileage under construction and completed in the United States on March 1, 1921, was 22,032 and the total estimated cost for this mileage is $361,946,868. Based on the total estimated cost of approved plans the percentage of types was approximately as follows:

Type	*Per Cent*
Earth	8.685
Sand clay	3.713
Gravel, plain and surface treated	19.823
Macadam, waterbound and surface treated	2.564
Bituminous macadam	6.346
Bituminous concrete	5,548
Portland cement concrete, plain and reinforced	38.464
Brick	4.799
Miscellaneous	4.040
Bridges	6.018
Total	100.000

During the war period road construction gave way to war activities. During 1919 and the early part of 1920 the rising costs of labor and materials indicated the desirability of a moderate program of construction to avoid undue absorption of labor and material supplies to the detriment of production in other lines of activity. Many of the states purposely delayed their road construction programs in the hope that prices would fall. This action affected all road construction, whether Federal Aid, projects paid for entirely by the state or by counties, towns and cities. During 1920 the added influence of extremely unfavorable railroad transportation conditions brought road construction nearly to a standstill.

During the latter part of 1920 many of the states apparently became alarmed because of the adverse railroad transportation conditions and to assist in bringing relief through truck transportation, resumed road construction. During the winter following the repressive influences appeared to be less in evidence. Now in the spring of 1921 with falling prices, an apparent over-abundance of labor and more favorable railroad transportation it is expected that the mileage of roads constructed during 1921 will be unprecedented in

*Chief of Bureau of Public Roads, United States Department of Agriculture.

the states having ample funds available. During 1920 a little over $91,000,000 of Federal aid road funds were put under contract and it is estimated that were it available between $125,000,000 and $150,000,000 would be put under contract during 1921.

Some of the states have already practically absorbed their total apportionment of Federal aid. Of these there are the twelve states of Delaware, Florida, Georgia, Idaho, Illinois, Louisiana, Maryland, New Hampshire, Oregon, Rhode Island, Washington and West Virginia. States still having a considerable balance of their apportionment available for new contracts are the nine states of Alabama, California, Indiana, Michigan, Missouri, New York, Texas and Wisconsin. In all of these last named states, however, it is expected that a large mileage will be put under construction during 1921.

As indicating in general the attitude that state highway departments are now assuming the following quotation is made from a statement by the Illinois State Highway Department:

"The indications now are that building conditions are gradually improving. We can safely look for cheaper materials and a larger supply of labor at less cost, as well as an improved transportation situation. It is possible that during the coming year (1921) we may see the cost of road building decreased to the prices prevailing in the spring of 1919 with a possibility of even a greater reduction in the following year. It is also the opinion of the majority of the prominent financiers of the country that within the next few months the forces now working towards a readjustment in all lines will bring about a corresponding readjustment of interest rates, which would mean the ability of the state to market its road bonds on a more satisfactory basis than at present."

It may be seen, therefore, that while during the war and later during 1919 and 1920 road construction where possible to carry it on at all was carried on under very adverse conditions, the prospects for 1921 seem excellent and just now I see no cause for worry about the progress of Federal aid road construction. Indications point to the construction of a very lengthy mileage. It is very fortunate that this is so because a large expenditure for road construction aside from the very considerable normal benefit which it will confer will very measurably diminish the force of the rising tide of unemployment. During 1922, unless additional Federal aid is granted there will be a very decided reaction in road building throughout the whole nation. It will be felt somewhat during the latter part of 1921 and the early part of 1922 in any event as the states in many, if not most cases, must legislate to meet any new Federal appropriation and the legislatures in quite a large number of states must be called in extra session as they have now adjourned for this year and do not meet again regularly for two years.

The consensus of opinion is that the expenditure of Federal funds for road construction has not only been a very profitable investment due to the great increase of property values, and the extension of transportation to the benefit of commerce and industry, but it has had a large educational effect, has encouraged and stimulated state and county road construction, has promoted co-ordination of road programs in different localities and measurably forwarded the adoption of better standards and better construction. As above stated, projects already under way will, within a a short time, exhaust the balance of the Federal funds now available, and on account of the tremendous value and importance of abundant good highways for agricultural, industrial and commercial interests, for their military importance and great value in supplementing overburdened railroad service, it seems vital that the work should be extended and provision made for it by the assurance of continued Federal appropriations of a substantial amount each year for a period of years.

Highway transportation is still far from a well-advanced stage of development, although great forward strides have been made in it. Highway production has always lagged behind the activities depending upon it. To-day on the eve of still greater activity the pressure of industry is such as to threaten the collapse of our main transportation system. The wealth of the nation has been increasing at the rate of approximately 10 per cent a year; the basic annual production of the country has been increasing at a rate in excess of 15 per cent a year; motor vehicle registration has been increasing at the rate of approximately 23 per cent a year; whereas the production of important highways has been increasing at the rate of about 6 per cent a year. It is very evident, therefore, that the production of surface roads is not keeping pace with the increase in wealth of the traffic of the country.

Federal aid has been a very great stimulus to highway production throughout the country. It has resulted in the establishment of state highway departments in every state. Through it has come about the training of a body of engineers capable of intelligently designing and supervising road work, the co-ordination of state highway departments to direct it, the development of important and abundant road building machinery, the provision of a large amount of construction plants and equipment by the states, as well as the building up of a corps of general contractors who have undertaken to do highway work. Through its influence more than forty states have already established the system of main roads that aggregate approximately 8 per cent of the mileage of rural roads in the United States. It has brought about a better understanding of the nation's needs for roads and a better understanding of the adjustment of road types to road traffic.

A large mileage of road must be improved, and while the most costly and most durable types are being adopted for the business centers it is also necessary to build a very large mileage of lower cost roads selected with proper consideration for local conditions and requirements.

It is believed there is no work more necessary, more pressing or more vital to our prosperity than a large highway construction program, and financial support by the Federal government seems advisable.

Lighting Highways

A new type of reflector developed especially for lighting country highways.

One of the features proposed for the "ideal section" of the Lincoln highway, concerning which much has been said recently (see PUBLIC WORKS for Feb. 19), is the lighting of the highway at night. An important advantage of this is the great reduction in accidents which would undoubtedly be effected. Partly because of this, it would also tend to increase night traffic and thus relieve day congestion and also increase the amount of service obtained from the road and increase the returns to the community from their expenditure on its construction.

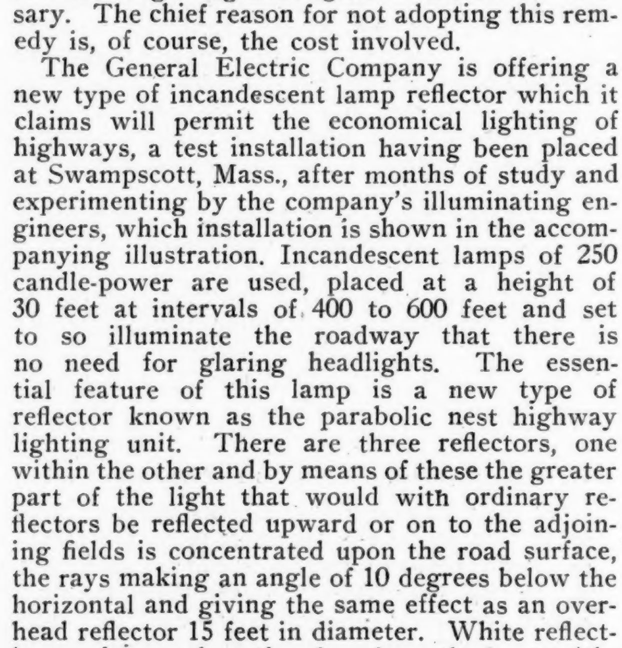
A large percentage of automobile accidents occur at night and a considerable portion of these are due to headlight glare. Many types of reflectors and lenses for headlights have been devised to reduce the danger from this cause, but with far from satisfactory success. Undoubtedly it would be much more desirable to have the highways as well as the city streets so lighted that the use of glaring headlights would be unnecessary. The chief reason for not adopting this remedy is, of course, the cost involved.

The General Electric Company is offering a new type of incandescent lamp reflector which it claims will permit the economical lighting of highways, a test installation having been placed at Swampscott, Mass., after months of study and experimenting by the company's illuminating engineers, which installation is shown in the accompanying illustration. Incandescent lamps of 250 candle-power are used, placed at a height of 30 feet at intervals of 400 to 600 feet and set to so illuminate the roadway that there is no need for glaring headlights. The essential feature of this lamp is a new type of reflector known as the parabolic nest highway lighting unit. There are three reflectors, one within the other and by means of these the greater part of the light that would with ordinary reflectors be reflected upward or on to the adjoining fields is concentrated upon the road surface, the rays making an angle of 10 degrees below the horizontal and giving the same effect as an overhead reflector 15 feet in diameter. White reflecting surfaces reduce the glare from the lamp without the aid of diffusing globes.

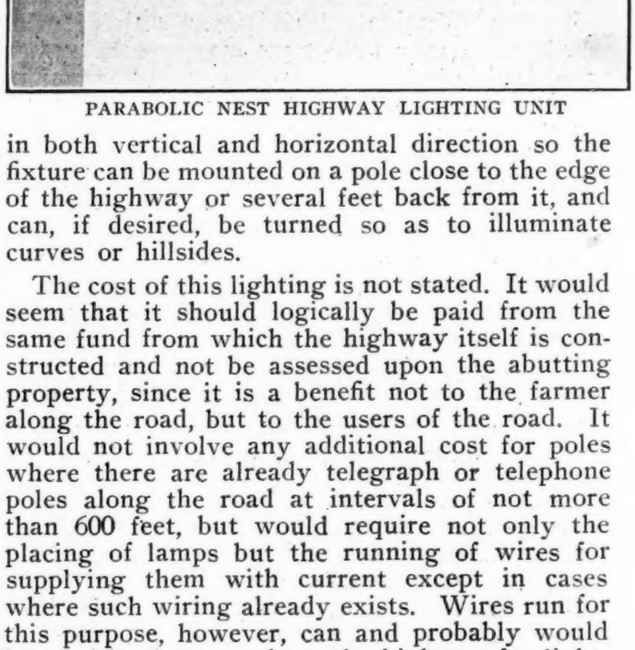
PARABOLIC NEST HIGHWAY LIGHTING UNIT

The bracket holding the reflectors is adjustable in both vertical and horizontal direction so the fixture can be mounted on a pole close to the edge of the highway or several feet back from it, and can, if desired, be turned so as to illuminate curves or hillsides.

The cost of this lighting is not stated. It would seem that it should logically be paid from the same fund from which the highway itself is constructed and not be assessed upon the abutting property, since it is a benefit not to the farmer along the road, but to the users of the road. It would not involve any additional cost for poles where there are already telegraph or telephone poles along the road at intervals of not more than 600 feet, but would require not only the placing of lamps but the running of wires for supplying them with current except in cases where such wiring already exists. Wires run for this purpose, however, can and probably would be used by farmers along the highway for lighting their houses or supplying current for farm and household electrical conveniences.



DAY VIEW OF PARADISE ROAD, SWAMPSCOTT



NIGHT VIEW OF PARADISE ROAD, SWAMPSCOTT

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No End to Road Work in View

More than three hundred thousand miles of rural public roads in the United States have been surfaced with more or less permanent construction at a cost of more than two billion dollars. This length would give one hundred transcontinental routes if concentrated in continuous east and west lines, or one for about every ten miles of latitude.

But large as is the amount of surfacing completed, there remains more than seven times this mileage that has not yet been surfaced. And as the country develops this mileage will be added to. There is therefore no immediate prospect of road construction work giving out.

But in addition to this, there is an enormous amount of maintenance and reconstruction work to be done. Last year about fifty million dollars was spent on maintenance alone, and it is realized that even more should be spent, and in the future must be spent, on this class of work if the roads are to be preserved from rapid and complete destruction.

Everlasting Roads

A Chattanooga paper, in commending the construction of a concrete highway in Hamilton county, Tennessee, on the pay-as-you-go principle, says: "The people of Hamilton county will have secured a permanent highway—a road that will last forever—twenty miles in length within the period of three years, and there will not be a bond outstanding to be taken up later because of it."

Any good roads advocate who tells the taxpayer that a concrete or any other road will "last forever" is laying up trouble for himself and a set-back for the good roads movement when, in two to five years, the taxpayers are disillusioned as to the everlastingness of the pavements. It does not pay in the long run to attempt to deceive them, and many are becoming wise to the untruth of such claims.

Automobile Fees

Most of the states are applying a part or all of the fees received from the registration of automobiles and licensing of chauffeurs, operators and dealers, to the maintenance or construction of roads. In 1920 $97,997,160 was so used, which was 96 per cent of the total amount of such fees collected by all the states. Even so, however, such fees provided less than a fourth of the total road expenditures. Were the fees doubled and all applied to road construction, they still would not pay as large a proportion of the cost as the deterioration due to automobiles is of the total wear of the roadways.

In fact, in most states practically the only wear is that caused by automobiles and this is being recognized. Illinois, Maine, Minnesota, Missouri, Nevada, Utah and Wyoming have adopted the plan of capitalizing the motor vehicle revenues for road construction, by issuing bonds and paying interest or principle or both from the motor vehicle revenue.

Distributing Road Construction Costs

The general idea at the basis of both federal aid and state aid in road construction is that the wealthier sections should aid the poorer ones in paying for roads through their territories, partly because these roads are used as through routes by inhabitants of the richer and more populous districts, and partly because the prosperity or poverty of any district reacts upon the entire state and country.

Some states, however, have not embodied this principle in their highway laws. In Kansas, for instance, "state aid" consists of collecting motor vehicle fees and handing over to each county 50 per cent of the fees collected in that county, which can be used for paying one-fourth of the cost of hard-surface roads built by the county. In Arkansas some of the poorer counties receive so little aid that they are using shot guns to prevent road construction by levying of taxes equal to a very large percentage of the entire value of their farms.

State compulsion rather than state aid will quickly rouse antagonism to good roads in place of the now almost universal approval of them, and cause a serious set-back to the movement.

Practical Solution of a Highway Problem

Construction problems, like any others, must be understood before they are solved, and after the cause of the difficulty and the desired remedy are determined, the simplest and most efficient economical practical remedies should be devised and applied. This is well illustrated by the description on page 326 of the successful methods for preventing injury by frost to concrete pavements adjacent to culverts. The engineer and contractor, who is an experienced road builder, lost no time in attempting to prevent the natural action of the frost but merely tried to remove the conditions that caused this action to be injurious to his structure. He noted that a certain part of the structure was necessarily exposed to the full effect of the frost and another part was exposed to no effect. And he therefore by a very simple and direct method provided for the actions between the two points so that they should be regular and under control and would operate in a way that the structure was designed to receive without injury. The results were all that he desired and he has established a construction detail that may be advantageously adapted for concrete pavement in cold climate and will save a large amount of injury to pavements and traffic and costly repairs and maintenance at a moderate initial construction cost. Engineers and contractors should emulate this direct method of investigation, analysis, and design, and whenever the work appears to be unsatisfactory or the behavior of a finished structure is not what is desired, the reason should be searched for and when found measures taken to eliminate it or, as in this case, to control it within practical limits, and design the structure to correspond with the definite requirements. Usually natural forces and operations can be directed rather than controlled or eliminated and the work should be designed and constructed so as not to require unnecessary resistance to them.

Pavement Bids in Gary

Bids on paving work were received on March 21 by W. P. Cottingham, city engineer of Gary, Ind. Sheet asphalt, asphaltic concrete, asphalt macadam, reinforced concrete, and sidewalk, curb and gutter were bid on. The sheet asphalt pavement consisted of 1-inch binder and 1½-inch wearing surface; the asphalt concrete of a 2-inch course with no binder course. Each of these are to be laid on the present pavement regraded. Bids were asked on use of Trinidad, Mexican and Texaco asphalts, and Trinidad and Mexican asphalts combined. The reinforced concrete pavement is one-course, 7 inches thick. The total of the low bids on the seven contracts was about $150,000.

All the work is to be paid for with bonds issued upon completion of the work against the property benefited. Bonds for work on Delaware, Pennsylvania and Madison streets and 19th avenue, in the center of the city, can be discounted by the contractors at about 5 per cent, says Mr. Cottingham, but those on the outlying streets carry a much greater discount and are not attractive.

Mr. Cottingham explains that "The low bidder on the sheet asphalt pavement resurfacing work —Municipal Construction Company—has a plant in town, left from last season's work here, and was very anxious to secure the work in the first letting and consequently cut its bid to make sure of it when it was seen that there would be some outside bidders."

This company bid $1.67 on Trinidad and $1.57 on Texaco and Mexican sheet asphalt on three streets and 10 cents more per square yard for each on the fouth; while one of the other bid $1.85 on Trinidad and Mexican combined and the other bid $3 on Mexican, in each street. These prices do not include regrading the present pavement or any work other than the paving proper.

For asphalt concrete the Municipal Construction Company bid 10 cents per square yard less than for sheet asphalt in each street, the second bidder 25 cents less, and the third did not bid at all. None of these three bid on work on the outlying streets, where the only bid was $2.75 for Trinidad and $2.60 for either Mexican or Stanolind.

For reinforced concrete a bid of $4.51 was made on 19th avenue and $3.77 and $4 on two outlying streets.

Asphalt macadam bids ranged from $3.50 on one street where there was only one bidder, to $2.25 on another street with two bidders.

Federal Report on California Roads

For several months past there has been severe criticism in many quarters of the work done by the California state highway department, the special criticism being that the millions spent by the state on roads have been practically thrown away, since the roads are too narrow for the volume of traffic using them and too thin for present-day truck traffic.

Those defending the work of the commission maintain that the insufficiency of the roads is not nearly as great as claimed by their critics and that even if it were, the commission was justified in adopting this type of construction by its ability thus to extend the road system into all sections of the state, which would have been far from possible had a wider and thicker road been built.

The subject is discussed at length in a report of the Bureau of Public Roads, which has recently been made public. This report says: "That the thin, narrow pavement and close grading en-

abled the rapid extension of very serviceable miles of roads is without question, and that the implied order in the Legislative Act of 1909 demanded extension, is equally evident. Because the second bond issue was voted in 1915, and the third in 1919 may, in a sense, indicate such a capacity for road financing by the state as to deny the assumption that the state of California, at any time, was obliged to take chances with thin pavement in order to produce mileage, but it is undeniable that the very extension of the pavement developed sufficient sentiment to provide additional money in 1915, and again in 1919.

"So it cannot be said in 1920, in the light of the fact that the great usefulness of the highway system is now proven, that the state would have realized its usefulness and provided in equal volume had not the system been extended as rapidly as it was, and at some sacrifice of either temporary or ultimate durability to increased mileage.

"Although for the most part the service rendered by the roads built is still uniformly good, it is very evident that the state can now well afford to raise the standard of construction. This standard must satisfy all motor vehicle operators. The increase in the use of the trucks will doubtless for a time be increasingly rapid. It has been over 500 per cent during the past three years, and will demand a greatly increased factor of safety in the pavement."

The cost of the roads to California is declared to be low. Prior to 1917 the average price of concrete roads, including grading and structures, is given as $1.14 per square yard, which is declared as "remarkably low." The price since 1917 has been $1.84, which the report says is also low.

The cost of the thin asphalt surface is given as between 8 cents and 9 cents per square yard. In the opinion of the Bureau of Public Roads this thin asphalt does not "serve a purpose commensurate with its cost."

Criticism of the specifications of the Highway Commission is voiced in the statement: "The original lean concrete mix of 1:2½:5 for a pavement should have been abandoned sooner," and that the requirements "for coarse aggregate with respect to size, grading, quality and cleanliness are, in the light of recent development, somewhat inadequate." It is declared that the present finishing can be improved. "The omission of transverse joints," the report says, "appears to have been a justifiable innovation particularly in a frostless country, but it is believed that there should be exceptions to this practice."

"The present requirements for a 1:2:4 concrete mixture," the report says, "if laid dry should produce a good pavement for traffic preponderantly rubber-tired, but it is noted that several states use a richer mix." The present specifications for reinforcement are declared excellent.

On the thinness of the concrete slab the report comments as follows: "This concrete pavement is the thinnest that has been extensively laid in any state, and would have been rejected as too thin in any state subject to winter frosts. It is one foot narrower than the minimum width of concrete roads built in most other states, and it is believed that under present general conditions it is at least 3 feet too narrow."

Heavier designed roads for sections where the sub-grade is adobe, clay or adverse soils is also advocated with a further recommendation for experimental construction.

The investigating engineers examined practically all the pavements in the state, 1,365 miles, and classified them as A, B, C, D, E and F; A being a pavement in practically perfect condition; D a pavement so cracked transversely and longitudinally that numerous small slabs are formed that, however, do not average less than 50 square feet area; E a pavement in which such slabs have an area less than 50 square feet but in which there is no general disintegration; and F, pavements badly broken and with disintegrated portions. They found only 12.5 per cent of the pavements to be in the last three classes.

Six hundred and thirty-eight cores were drilled in the pavement, these having 4½ inches diameter, the object being to determine the depth of concrete, the strength, analysis of constituents, etc. "Measurements showed a surprisingly close average of 50 per cent coarse aggregate in both the 1:2:4 and 1:2½:5 concrete." The depth varied considerably, but in general ran greater than the specified four inches. The average compression test, corrected for cylinders 9 inches high by 4½ inches diameter, averaged well above 3,000 pounds; but there appeared to be a slight decrease in compressive strength with the age of the concrete.

It appeared that there was little if any decisive evidence that reinforcement in 4-inch or 5-inch concrete has proved effective on the adobe and other adverse soils.

The engineers believe that special treatment will be necessary for adobe and clay soils in addition to increasing the thickness to 5 inches. This may consist of increasing the thickness to 6 inches and possibly some corrective treatment of the sub-grade such as mulching the shoulders to prevent evaporation and giving the sub-grade less crown. It is proposed that short sections of tentative design should be built as frank experimental construction to determine the workability and economical design for roads on such soils.

The report states that the financial administration has been "scrupulously honest," that the system was well planned, and that most of the reasons for criticism were brought about by an effort to produce the largest possible mileage with limited funds.

Location, Grading and Drainage of Highways

A book with the above title has just appeared written by Wilson G. Harger, engineer in the New York Department of Highways and one of the authors of Harger & Bonney's "Highway Engineers' Hand-book." This is stated by Mr. Harger to be the first of a series of four volumes, the other three of which are in preparation, which are to cover the entire road problem from the standpoint of the constructing engineer. This volume discusses general principles governing the

policy of highway programs, while the future books will be devoted to selection of pavement type, methods of construction, maintenance and reconstruction, detail methods of field and office work, and construction engineering and inspection.

The six chapters in this volume are entitled: "General Principles of Economical Highway Design," "Proportion and Economy in Design," "Classification, Route and General Engineering Location," "Grades and Alignment," "Cross Sections of Rural Roads, Widths of Pavement, Right of Way Clearing," "Drainage." These subjects are discussed quite fully in 278 pages of text, well illustrated by diagrams and appropriate photographs, maps and detail sheets, and contain a considerable amount of tabulated data of various kinds. Throughout there is evidence that the author is familiar from practical experience with the subject of which he writes. It is believed that no student or practicing engineer in highway work can fail to obtain much valuable information from this book.

Preventing Cracks in Concrete Pavements Near Culverts

Well drained stone foundation of graduated depth eliminates injurious frost action by regulating displacements.

Considerable damage is often done to concrete pavements near culverts because of the irregular action of the frost in displacing the culvert and the adjacent pavement. When, as is usual, the foundations of the culvert are carried below frost line and the foundation of the pavement is not carried below frost line, the action of the frost under the pavement results in a heaving motion which raises the pavement while the foundations of the culvert, being below frost level, are not raised. This causes a relative vertical movement between the pavement and the culvert which results in shearing the concrete if no expansion joint is provided along the edges of the culvert.

The top of the culvert remains at the normal elevation while the pavement is raised more or less according to the depth of the frost line, the amount of material frozen above it, and the severity of the frost. When the pavement is laid directly on the earth, or with a considerable volume of porous surplus material beneath it that can be saturated and frozen, the heaving action may raise it from ½ inch to 1½ inches, as was the case at a culvert on route A, section 1, of the New Jersey State Highway, which is illustrated by sketch.

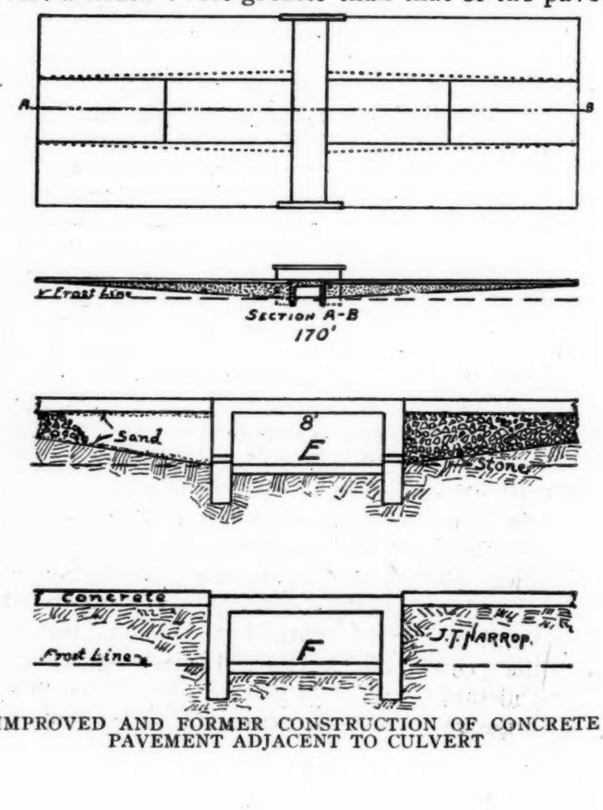
This condition, of course, exposes a sharp transverse edge of concrete to impact and attrition, and causes it to be worn and rounded. When the ground thaws and the pavement settles again in the spring and summer, it in turn exposes a sharp corner of the culvert which is similarly worn and rounded, making a transverse gutter across the full width of the pavement. The pavement does not settle quite to the original position on account of the loose materials filling in under it, and the defect once started grows worse and worse and is a menace to traffic.

PREVENTING THE INJURY

Although it is not practicable to eliminate the action of frost along the entire roadway nor to prevent displacement, both can be done for limited distances and the movements can be so adjusted and regulated as not to injure the pavement. This has been successfully accomplished as shown by detail E, and by the plan and section which illustrate the correction applied by the John B. Harrop Company, engineering contractors, Garfield, N. J., to the New Jersey road that was injured as shown in detail F.

Acting on the principle of the total elimination of the displacement of the pavement adjacent to the culvert and the gradual increase of displacement from the culvert to a remote point on each side of it where it becomes equal to that of the regular road surface without concentrating stresses or rigidly maintaining fixed positions, Mr. Harrop treated the pavement for a distance of 80 feet longitudinally each side of the culvert so as to control the frost action over this space of a total length of 170 feet, reducing the frost action gradually from normal at the extremities to nothing at the center.

This was accomplished by excavating the entire length of the section to form inclined planes starting at sub-grade at the ends and descending to at least 18 inches below sub-grade and below frost line at the culvert. The inclined surfaces were first covered with 2 inches of cinders or coarse sand well tamped and having at the culvert a width 4 feet greater than that of the pave-



IMPROVED AND FORMER CONSTRUCTION OF CONCRETE PAVEMENT ADJACENT TO CULVERT

ment, and, at the ends of the section, a width equal to the regular width of the pavement.

On these inclined surfaces broken stone 1½ or 2½ inches in diameter was filled in up to sub-grade level for the whole length of the section. The stone near the culvert was well tamped with hand rammers, and all of it was placed in layers and thoroughly rolled. The rolled surface was covered and sealed with sand or stone screenings, providing a solid surface to support the concrete pavement up to th second expansion joint each side of the culvert.

After the concrete pavement was restored up to the culvert, the drainage under ran freely through the broken stone and escaped through weep holes in the culvert wall, preventing freezing in the stone fill.

As the fill extended below frost line at the culvert, no movement took place here and the surface of the pavement remained always at the same elevation as that of the culvert thus developing no dislocation or strains between the two adjacent structures. As the depth of the stone fill diminished on each side of the culvert the bottom of the stone fill gradually rose above the frost, resting on porous material, greater and greater quantities of which might freeze and heave the concrete pavement more and more as it receded from the culvert until at last the maximum amount of heaving was permitted at the second expansion joints, where divergence between the horizontal and inclined surfaces of adjacent pavement slabs could take place without injuring them. The displacement here, however, was the same as that of the untreated pavement and at the first expansion joint beyond the culvert the displacement of both sides of the joint was also the same so that no injury or relative movement of the surface of the pavement occurred, and no matter what the position or the total amount of upheaval, the two slabs nearest the culvert on both sides always maintained horizontally or inclined positions without injury to themselves or the expansion joints.

The increased width of the bottom of the stone fill at the culvert was provided to prevent earth from being washed in under the edge of the concrete. The work described above has proved very satisfactory and cost (in 1920) about $250.

Increased Highway Costs in Oregon

The rapid increase in wages and prices on highway work in Oregon during the years 1915 to 1920 is very clearly shown in the tabulation which appears below. These prices are all strictly comparative and represent average prices on materials F. O. B. Portland, Ore., and average wages paid on highway work in the immediate vicinity of Portland.

ITEM	Unit	1915	1916	1917	1918	1919	1920	Percentage Increase 1915 to 1920
Labor	Day	2.00	2.50	3.00	3.50	4.50	5.00	150
Man and Team	Day	5.00	5.50	6.00	8.00	9.00	11.00	120
Trucks	Hour	2.50	3.00	3.25	3.50	3.50	3.50	40
Cement	Net Bbl.	1.90	1.95	2.79	2.79	2.79	3.60	90
Asphalt	Net Ton	14.50	14.00	15.55	19.50	23.50	24.00	65
Steel (Reinforcing	Cwt	3.30	4.50	6.00	4.90	4.40	5.00	50
Lumber	M-FBM	32.00	38.00	40.00	50.00	65.00	65.00	100
Powder (40%)	Cwt.	14.00	16.43	21.50	22.25	19.75	21.05	50
Sand	Cu. Yd.	.60	.75	1.00	1.10	1.25	1.50	150
Gravel	Cu. Yd.	.70	.90	1.00	1.10	1.25	1.50	115
Broken Stone	Cu. Yd.	1.15	1.15	1.25	1.45	1.85	2.00	75
Freight (25-mile haul)	Ton	1.20	1.20	1.20	1.50	1.50	1.90	60

Road Improvement and Drainage

Data from more than 500 counties, furnished by county highway officials, giving the total mileage of roads; miles graded, macadamized or graveled, or otherwise improved; the miles drained by deep side ditches, miles drained by underground drains, and some details of drainage.

The data given in the table which occupies the next few pages have been furnished us during the past few weeks by engineers and other officials in charge of county highway work in nearly all of the states. While not all of the counties in the country are represented here by any means, the number is sufficiently great and scattered over the country with sufficient uniformity to give a general idea of conditions throughout the United States.

Following this table is another giving information concerning statewise conditions furnished by state highway officials, and among the data in this latter table will be found the miles of improved roads and miles of unimproved roads in the state. One of the rather remarkable features of these figures is the considerable number of states in which the mileage of improved roads is aproximately 10 per cent of the total mileage of roads in the state; this being the more remarkable when we notice in the county figures the great variations in this respect, some counties having less than one per cent of their mileage improved, while others have nearly 100 per cent improved.

Another interesting feature is the considerable amount of public roads in many of the states which have not even been graded. In general, however, about 30 per cent to 50 per cent of the roads are reported as having been graded.

In spite of the recent development of hard surface highways, it will be noticed that by far the largest part of the surfacing reported from the various states is macadam or gravel, there being almost ten times as much of this as of all other kinds of improved surfaces.

(*Continued on Page* 334)

ROADS UNIMPROVED, IMPROVED, AND DRAINED

Note: Quantities are given in miles unless otherwise stated

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Alabama:							
Calhoun	1,100	80	70	.....	one-third	none	......
Conway	275	157	39	.....	5	.....	......
Monroe	2,400	205	30	none	205	none	......
Montgomery	650	500	450	15 sand clay	all	none	......
Pike	1,200	150	none	150 sand clay	.....	.....	D. S. V. pipe
Arkansas:							
Jackson	250	75	40	none	5	none	shallow side ditches
Lincoln	150	50	15	none	.....	none	......
Polk	290	160	none	none	100	none	none
Saline	350	116 2-3	35	none	.....	none	......
Scott	300	200	none	none	100	none	......
Sevier	220	73 1-3	22	none	.....	none	......
Van Buren	300	50	none	none	50	none	none
California:							
Fresno	5,000	3,000	25	none	none	none	none
Glenn	600	540	300	34	240	.....	......
Madera	2,000	1,500	10	26	very little	none	......
Solano	750	all	5	50 conc. & cem.	all	none	none
Sutter	600	400	200	30	150	none	......
Ventura	600	400	....	150	.....	.....	......
Colorado:							
Elbert	200	100	30	none	50	none	Iron culvts. used
Logan	4,200	3,000	200	.....	5-6	none	......
Ouray	300	100	5	none	none	1	tile
Rio Blanco	450	40	29 shale	none	75	none	......
Rio Grande	350	all	250	No hard surf. rds.	none	26	Land drainage drains wooden box & vitr. drain tile
Routt	1,800	none	none	none	180	none	none
Wild	7,800	2,500	700	.....	.....	25	vitr. tile
Connecticut:							
Bethlehem	180	3	2½	½	all	none	......
Greenwich	180	80	20	20	20	.....	......
Hamden	400	100	50	50	90	10	tile sewer pipe
New Haven	15	5	3 cement 2 mac.	3	all	.....	......
New London, Windham and Tolland	1,068	30	289	13.5 conc., 35.5 bit. mac.	none	5	rubble drain
Florida:							
Bay	250	160	60 clay gravel	none	4	none	V.C.P. wooden bridges for drainage openings
Bradford	500	300	none	.....	300	none	......
Duval	200	300	....	10-12 brk.,conc.,asp.	....	none	open ditches
Escambia	1,500	....	10 gravel	3½ conc.	.....	none	......
Flagler	140	110	5 rock	none	20	none	......
Pinellas	395	395	50	95 vitr. br.	200	none	......
Idaho:							
Ada	600	200	100	25 pav.	25	none	......
Bannock	1,000	400	50	4 cind. & grav.	100	none	......
Boise	500	....	none	none	none	none	......
Butte	550	25	7 gravel	none	25	none	......
Caribou	383	122	none	.....	all	none	......
Custer	526	38	10	none	none	none	......
Dist. No. 1	324	324	57	none	none	none	side ditches & cu v.
Idaho	500	150	15	none	.....	none	......
Power	700	350	80 gravel	.....	200	.....	......
Illinois:							
Adams	1 650	235	100	2 conc.	235	none	......
Calhoun	350	none	2	none	none	none	none
Carroll	700	100	55	2½	70	1	4 in. & 6 in. farm tile laid 3 ft. to 4 ft. dp. on one side of rd. in side ditches
Christian	1,269	700	none	80 oiled earth	40	20	tile
Clark	1,000	1,000	130	25 pavement	1,000	none	......
Coles	865	600	175	50 brk. pave.	all graded rds.	25	tile
Crawford	800	nearly all poorly	50	90 gravel, 5 conc.	.....	practically none	......
De Witt	732	300	none	50	50	.....	......
Fulton	1,500	1,300	....	30	very few	.....	tile
Henderson	619	400	2	none	400	1	tile
Jackson	1,500	1,000	20	¾ mi. brick	100	2	tile
Jasper	900	700	none	none	10	2	ti'e
Jersey	634	all	3	¾ conc.	.....	3	tile
Kane	865	300	300	21	.....	.....	......
Madison	1,175	all	22	89.5	200	none	......
Marion	1,200	300	1	2 conc.	500	none	......
Massac	400	all	100	none	numerous	none	none
McDonough	1,095	500	none	none	50	40	tile
McHenry	1,008	1,000	750	3½ conc.	short stretches	3	tile
Monroe	600	150	25	1¾ conc.	300	none	......
Piatt	600	350	....	7 brick	300	300	tile
Pike	....	2,000	40	1½ conc.	50	only those showing decided seepage	tile
Pulaski & Alexander	965	all	110	none	600	1	tile
Richland	800	600	15	none	500	.....	......
Saline	600	....	3	17	.....	none	......
Schuyler	800	300	1	5	25	1	tile
Scott	400	....	none	20	.....	.....	mostly open ditches at roadside
Stephenson	1,080	700	100	5	750	2	tile, ½ mi. brick lateral gravel drains
White	1,002	590	75	.....	500	none	......
Williamson	860	25	°	17	all	.....	......
Woodford	900	890	15	5	890	100	tile drains

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Indiana:							
Clinton	839.44	all	833.92	5.52	all	none	......
Crawford	1,600	150	80	none	230	none	......
Decatur	750	750	400	8	all	very few	side ditch & cross drains
Dubois	750	100	100	none	none	none	none
Fulton	2,000	none	200	none	none	none	tile
Howard	700	650	495	10	650	8	red drain tile
Jackson	1,500	1,450	750	50	1,000	1	tile drains, burned clay field tile
Jennings	1,000	nearly all	400	none	25	none	side ditches not deep enough, many filled up
Madison	1,100	1,100	950	34	all	none	......
Montgomery	600	....	550	.....	.....	.....	......
Morgan	1,000	385	385	10 brick, ½ mac.	all	none	......
Newton	634	600	333	none	300	30	......
Putnam	1,200-1,300	....	930	.....	all	2	tile
Ripley	6,000	350	339	1 conc.	none	none	......
Shelby	1,000	....	500	4 conc.	none	none	......
St. Joseph	834	all	40	60	100	2	clay drain tile, also some trench drain
Tippecanoe	980	976	680	15	.....	75	tile where a 2 ft. ditch is insufficient
Vigo	850	450	425	25 bk., conc.&vibr.	2 or 3	5	6-in. tile
Iowa:							
Allamakee	1,100	35	none	none	150	none	none
Appanoose	1,008	200	none	none	4	none	......
Beton	1,160	300	none	⅝	300	5	5-in., 6-in., 8-in. drain tiles
Bremer	864	5	2	none	125	15	tile drains
Buena Vista	1,100	170	135	none	none	all	tile drain
Cass	1,500	5	none	½	none	none	......
Cedar	950	14	2.25	none	400	very little	clay tile
Cerro Gordo	1,074	75	4	21	.....	260	tile drains (clay & conc.)
Chickasaw	1,100	1,000	50	.....	1,050	120	tile drains
Clay	1,000	205	142	none	none	150	conc. or clay drain tile some surf. water inlet
Crawford	1,390	131	none	none	3	none	......
Dallas	1,100	70	48	none	1,000	300	6-in. drain tile
Delaware	900	600	30	none	none	20	tile
Des Moines	761.6	50	5	1 conc.	almost all	15	farm tile
Dickinson	350	80	45	none	none	20	6-in. tile
Dubuque	1,000	50	30	4	.....	.....	tile
Emmet	750	106	99	none	.....	32	tile
Floyd	1,000	35.50	20.16	11.56 conc.	.....	40	tile
Grundy	1,000	300	6	none	200	15	tile
Guthrie	....	....	2	earth	.....	.....	vit. tile
Hamilton	1,000	91	90	none	10	300	6-in. tile
Harrison	170.5	14	none	none	.....	none	......
Iowa	1,225	730	none	none	78	16	tile drains
Johnson	1,100	800	none	none	500	.....	......
Kossuth	1,800	50	13.5	none	100	50	tile
Linn	1,400	10	27	3½	1,200	30	6-in. tile
Lucas	800	100	none	none	100	none	none
Lyon	1	199	8	0	8	1	clay-tile-drains
Madison	1,130	1.50	none	none	all	.....	......
Mahaska	1,100	400	none	none	1,000	60	tile
Marshall	....	....	5	.....	.....	1	6-in.-8-in. drain tile
Monona	1,368	7	none	none	166	none	......
Monroe	500	10	....	.....	.....	.....	......
Montgomery	990	15	none	.....	.....	.....	......
Muscatine	742	32.80	10.08	0.4	111.57	.....	tiling
O'Brien	1,125	860	none	1	2 ft. below shldr.	25	5-in.-24-in. clay & conc. tile drains
Palo Alto	822.36	160	14	2 conc. pav.	3	30	drain tile with numerous ditches
Pocahontas	115.7	21.4	63	.....	none	some in each mile	6-in. drains-tile
Sac	1,100	150	80	none	300	75	5-in.-12-in. tile drain
Scott	695	50	70	2 brick, 8 base for brick	.....	15	tile drains
Tama	140	20	none	none	all	5	tile
Union	1,325	all	none	none	none	5	6-in. tile
Van Buren	700	200	none	none	all	1	6-in.-10-in. tile
Wapello	1,200	10½	none	none	4	5	tile drain
Warren	1,100	none	none	none	none	none	none
Webster	102	9	0.5	none	.....	15	6-in. tile w. intakes
Winneshiek	1,000	none	none	none	none	none	none
Worth	800	300	50	none	none	30	tile drains
Kansas:							
Allen	1,056.5	90%	42.5	0.92 conc.	none	none	......
Anderson	1,152	all	18	none	all	none	......
Atchison	928	all	6	3½	100	½	tile
Barber	1,115	400	12	.....	none	none	......
Barton	1,873	1,221	3	5¼	160	none	......
Brown	1,159⅜	none	none	none	none	none	side ditches
Cherokee	1,185	1,000	130	.....	all	none	side ditches
Crawford	1,190.58	all	28	none	1,140	none	......
Elk	1,000	700	20	.....	700	.....	......
Ellsworth	121	all dirt surfaced	....	.....	.....	.....	......
Finney	1,050	325	5	10 sand clay	none	none	......
Geary	630	370	10	8 conc., 2½ brick	5	none	......
Graham	1,400	300	none	none	200	none	culverts
Greeley	250	80	none	none	none	none	none
Harper	180	all	25	none	none	none	......
Johnson	1,020	all	25	100	.....	short stretches	tile
Kingman	1,500	216	none	30 sand clay	6	none	......
Labette	1,400	210	20	none	60	none	......

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Kansas (continued):							
Lyon	240	200	2	1 conc.	20	none	......
Marion	1,700	100	none	none	none	none	......
McPherson	1,869	1,400	6	dirt	all	none	......
Meade	770	700	none	none	500	none	......
Mitchell	1,132	700	none	1½ conc.	200	none	......
Montgomery	1,275	1,100	19	3	175	none	none
Nemaha	1,460	500	....	.....	10	.....	......
Norton	1,501	500	none	none	all	none	......
Osage	1,153	173	none	none	all	none	......
Pawnee	1,936	[illegible]	2 gravel	none	all	none	......
Russell	1,500	250	none	none	all	none	......
Sedgwick	1,958.92	1,500	....	46	207.7	.....	......
Shawnee	986	250	50	10 conc.	250	2	catch basins & sewer tile
Smith	1,820	all temporary	none	none	nearly all	none	......
Stafford	1,200	500	none	none	none	none	none
Wabaunsee	1,500	1,000	5	none	.....	none	......
Kentucky:							
Allen	300	75	60	7 crushed stone	none	none	natural slope with medium ditch
Barren	1,300	500	200	none	none	none	none
Bracken	400	300	275	.....	.....	.....	ordinary
Daviess	750	107½	104	1 rock asp.	none	none	none
Fleming	700	350	300	none	700	none	......
Gallatin	250	155	155	none	200	none	none
Hopkins	670	23 graded	mac.	9 cinder	all	none	......
Mason	400	300	300	.....	150	.....	......
Montgomery	300	130	130	none	100	none	......
Morgan	1,200	3	none	none	25	.....	......
Oldham	250	200	125	.....	100	.....	......
Owen	600	400	400	12 surf. treated	.....	none	......
Pike	310	15	....	.....	all	none	......
Rockcastle	500	48	12	none	none	none	......
Shelby	450	500	450	20	500	none	......
Whitley	400	83	10	none	83	none	stone & concrete culverts, pipe culverts
Louisiana:							
Avoyelles	600	100	35	.....	100	.....	......
Caldwell	150	85	7	none	85	none	corrugated & V.C. pipe; concr. culverts
Maine:							
Knox	3,000	50	10	40	50	none	......
Maryland:							
Kent	425	200	3 gravel 20 mac.	16 conc.	none	few	4-in.-6-in. underdrain
Massachusetts:							
Athol	140	40	10	.....	.....	.....	tile
Michigan:							
Alger	300	200	35	earth	none	none	......
Cass	1,600	250	175	7	none	none	......
Dickinson	150	80	80	.....	none	none	none
Eaton	1,200	250	230	none	1	2	tile drains
Emmet	800	....	27	25	.....	none	......
Grand Traverse	....	100	gravel	very few	.....	.....	......
Kalkaska	200	180	100	5 stone	none	none	......
Lapeer	....	....	100 gravel	none	.....	.....	......
Luce	350	120	37	.....	9	.....	......
Macomb	1,300	300	266	34	4	1	12-in. 18-in. vit. pipe
Mason	300	220	190	none	6	none	......
Missaukee	685	some on all	138	.....	3	.....	open
St. Joseph	....	78	78	.....	.....	.....	......
Minnesota:							
Aitkin	260	200	49 gravel	.....	100	none	......
Big Stone	436	400	30	none	none	none	......
Blue Earth	200	111.5	89	8.5 oiled	25	40	clay & cem. tile dr.
Brown	900	all somewhat	150 grav.	none	200	none	......
Carlton	700	400	96 gravel	6 sand clay	.....	.....	......
Carver	240	40	40 gravel	.....	40	none	......
Chippewa	960	300	50 gravel	none	10	100	tile, cement, clay
Chisago	850	200	87	none	100	19	6-in. tile
Cottonwood	1,300	500	35	.....	50	none	cross tile drains
Dodge	906	....	66	none	none	none	......
Faribault	1,200	120	21	none	indef.	10	cement & clay tile
Goodhue	900	100	60	5 conc.	.....	.....	......
Grant	110	60	30	none	60	2	tile drains
Hubbard	....	150	none	top soil	3	none	......
Isanti	750	4.5	38.5	none	.....	.....	......
Jackson	1,364	100	25	none	100	15	clay & conc. tile
Kandiyohi	1,200	75	50	4 conc.	none	9	6-in. tile drains
Lac Qui Parle	1 300	200	125	.....	300	.....	......
Lincoln	1,000	150	52	none	all that is graded	none	......
Lyon	1,620	420	117	none	200	.....	......
Marshall	....	100	45	.....	15	.....	....
McLeod	800	141.75	141.75 grav.	.....	8	4	tile
Millelacs	123	99	67	2 mac.	99	none	none
Nicollet	745	500	400 gravel	none	.....	10	conc. tile
Nobles	....	90	50	6	80	4	tile
Pope	1,200	90	70 gravel	none	.....	.....	tile
Redwood	245	220	190	none	2	2	clay & conc. tile
Roseau	2,633	130	41.5 gravel	3.5 sand clay	130	none	......
Stearns	2,100	1,000	500	.....	.....	.....	......
Steele	500	300	200 gravel	none	none	none	none
Stevens	1.53.3	97.1	16.84 gravel	5.599 conc.	none	none	......
Swift	1,500	300	80 gravel	7.4 conc.	75 by drainage ditches	60 tile drains	tile drains
Wadena	600	....	3 gravel	3 sand clay	25-30	none	......
Winona	650	125	45.2 mac. 52.3 gravel	14.9 conc., 3.2 brk.	100	none	......

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Mississippi:							
Adams	237	38	34	none	none	none	1 in. deep
Benton	300	11.8	none	none	1	none	......
Lafayette	700	300	4	none	.....	.....	......
Lincoln	500	160	160	none	none	none	......
Lowndes	1,000	750	300	75 sand clay	750	750	D.S.C.V. pipe, corr. iron pipe, culv.
Missouri:							
Butler	750	400	none	none	many	none	various
Caldwell	800	all	none	5 with oil	all fairly well drained	none	......
Carter	....	37	none	.....	37	none	......
Cedar	200	100	25	none	125	.....	......
Clark	400	100	none	none	none	none	grader side ditches
Cooper	1,100	....	150	none	.....	.....	......
Henry	1,040	800	none	.....	all those drained	.....	......
Lincoln	1,256	485	170	none	none but good grading	none	none
Macon	816	all partially some fairly well	none	dirt	all shallow	none	none
Mississippi	515	300	none	5½	200	70	tile
Monroe	1,000	all somewhat	30	none	½	none	......
Ozark	800	100	none	none	none	none	......
Perry	950	400	225	none	300	none	......
Putnam	400	all to some extent	none	none	none	none	natural drainage
Ralls	900	all	50 gravel	.....	150	.....	......
Schuyler	625	all	none	none	all	none	......
St. Clair	....	500	4	.....	all	.....	......
Sullivan	1,200	small amt.	none	.....	.....	.....	......
Montana:							
Beaverhead	1,300	700	10	none	.....	.....	side ditches culv.
Big Horn	662	408	7 gravel	none	all	none	......
Blaine	1,200-1,300	500	40	none	60	none	......
Carbon	1,500	200	26	2 cinder	20	none	......
Chouteau	6,000	1,200	none	none	1,200	none	......
Fergus	4,500	600	12	½ conc.	612	none	......
Flathead	2,000	500	80	.....	80	none	surface
Granite	350	150	20	none	20	none	......
Hill	800	200	15 gravel	none	20	none	......
Madison	1,100-1,400	240	15	none	20	none	ditches made by blade grader
Meagher	620	206	39	none	5	none	......
Musselshell	1,500	1,000	1	4 cinders	none	none	side ditches with drains, culverts, conc. pipe
Prairie	640	220	27 gravel	none	none	none	......
Stillwater	1,100	500	1	none	none	none	......
Teton	605	200	25	none	none	none	......
Valley	2,800	250	3.3	none	none	none	......
Wheatland	350	175	10	.....	.....	.....	......
Yellowstone	2,500	1,800	50 gravel	2 conc.	most of grad. rd.	.....	......
Nebraska:							
Antilope	....	500	3 gravel	none	100	none	open ditches
Dakota	560	125	none	none	125	none	......
Deuel	co. is 15x31½	412	21-22 grav.	none	none	none	none
Dodge	1,080	1,064	10 gravel	6 paved	.....	.....	......
Hooker	55	14	9	10	1	none	open ditches
Knox	1,500	1,000	2	none	50	none	......
Morrill	200	75	gravel	none	50	none	......
Otoe	1,300	900	none	.....	125	.....	......
Rock	500	25	none	5	20	none	ditches
Saline	1,100	60%	none	none	10%	none	open ditches
Sherman	200-300	100	none	none	100	none	......
Wayne	900	600	none	dirt	50%	10	8-10 in. drain tile
New Jersey:							
Burlington	1,500	350	200	50	.....	.....	......
Cumberland	700	600	1½ mac.	.....	none	none	......
Hunterdon	1,000	100	80	8 pen. mac.	none	several mi.	French drains
Mercer	.....	150	133	15	135	25	French drains, tile drains
Passaic	211	all	155	56	.....	2	French drains
Southern Division	220	205	130	15 bit., 60 conc.	none	10	French drains
Sussex	950	80	80	none	15	30	stone, & 6-in. tile and stone
Union	797	700	233	119	none	10	4-6 in. pipes, 30 in. deep, in stone filled trench
New York:							
Broome	1,250	all	75	5	20	.....	tile
Cayuga	1,490	75%	mac. 160-gravel 300	15 conc., 90 bit., 15 mac.	.....	small sections	tile & French drains
Chenango	1,746	1,746	105	65	1,500	25	4-6 in. tile
Franklin	135	....	....	.....	.....	.....	......
Jefferson	2,200	600	500	100	60	none	......
Madison	1,422	1,422	275	.....	400	.....	......
Monroe	1,330	1,330	1,038 mac., 244 gravel	8	.....	.....	......
Nassau	90	70	46.65	18	2	none	none
Niagara	934	800	24 brick, 85 conc., 150 oiled, 200 W. B. & stone	50 gravel	nearly all	1½	farm tile
Orleans	720	720	....	.....	720	none	......
Oswego	1,714	900	337	425	none	none	......
Otsego	2,251.50	200	146.75	13 conc., 2.01 Top.	.....	.....	......
Yates	769	600	20	10	700	2	3-in. tile

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
North Carolina:							
Beaufort	1,400	800	none	10	.....	none	......
Buncombe	400-500	150	75	35	all that is graded	none	......
Craven	200	100	10	50 brick	.....	.....	......
Durham	800	200	109	20	.....	none	......
Lenoir	120	40	none	12 asp.	25	5	tile
Randolph	1,500-1,750	500-600	350 grav.	none	.....	10-25	tile & metal
Washington	200	200	none	50 sand clay	30	none	shallow causeway ditches
Watauga	200	50	none	none	.....	.....	......
Wayne	1,200	500	50 gravel	300 sand clay	.....	.....	......
Wilkes	450	250	none	110	.....	.....	side ditches & drain tile
Wilson	700	200	16 mac.	90	all shallow	none	......
Yancey	700-800	40	2	none	12	none	......
North Dakota:							
Barnes	....	500	10	none	125	none	......
Grand Forks	1,000	500	40 gravel	none	150	none	triangular & flat bot. ditches
Grant	500	200	5	none	10	none	......
McIntosh	....	20	none	none	20	none	open
McKenzie	1,800	100	none	none	20	none	......
Mountail	3,060	500 dirt	none	none	.....	none	corr. metal culvs.
Pembina	1,100	half	none	.....	50	none	open drain
Pierce	....	50%	50	6 clay surface	10	none	none
Ward	2,700	100	10 gravel	none	none	none	none
Ohio:							
Allen	970	all	900	5 brick, 11 mac.	all, but not very deep	300	clay tile
Ashtabula	1,280	....	35.6 mac., 60 gravel	100	.....	.....	tile
Carroll	900	18	12	6	.....	none	side ditches
Champaign	800	700	700	25	.....	.....	......
Clark	878	all	720	158	60	4	farm tile
Clermont	990.04	569.75	420.25	1.04 conc.	none	none	none
Clinton	756	700	620	3	5	none	......
Columbiana	1,251	10	62.87	72.79 brk., 1081 conc.	50	none	......
Coshocton	1,265	26	12.5	13.5	none	none	none
Darke	1,292.56	1,069.91	1,044.08	25.83	8	65	field tile in gravel in side ditch
Erie	1,116.30	400	41.2 gravel 248.30 mac.	30.70	8-10	.....	tile
Fairfield	1,000	....	700	5	all	.....	......
Fayette	650	all	all	8 brick	all 1 in. to 2 in. deep	none	......
Fulton	882.88	882.88	323.88	½ brick	.....	.....	......
Henry	972	417	597.25	none	all	.....	tile
Highland	1,077.1	560.98	182.03 mac., 330.59 gravel	3.5 marl.	100	none	......
Holmes	1,000.74	39.89	15	7.55	39.89	none	......
Jefferson	1,019	650	245	20	.....	none	......
Licking	1,410	400	425	26	150	2	tile & French drns.
Marion	787	....	500	1 brick	501	.....	......
Meigs	999.6	60	4.75	16.30	1	.....	open ditches
Ottawa	595	95%	200	12 conc., 8 brick	100%	.....	......
Pickaway	802	639.6	22.9	5.3	.....	.....	......
Putnam	1,111.2	....	587	1 conc.	.....	900	tile
Richland	1,310	800-900	244	3 brick, 6 conc.	130	4,100 lin. ft.	field tile
Ross	1,093	....	....	.....	.....	.....	......
Sandusky	950	900	503	42	500	200	clay tile
Summit	870	all dragged	16	58 brick, 36 conc.	.....	.....	tile, with cinder or gravel
Trumbull	1,171	450	350	40	300	14	tile
Tuscarawas	1,322	200	102.6	47.74	.....	.....	......
Union	828	all	661	6½	all	75	drain tile
Warren	789	....	20 mac.	2.48 conc.	none	none	side ditches
Williams	953	900	144	9	500	very little	ditches or farm tile con. with catch basins
Oklahoma:							
Beckman	2,500	600	none	25 sand clay	100	none	......
Bryan	2,500	200	none	.....	.....	.....	......
Carter	1,600	600	37	none	.....	none	......
Choctau	722	350	none	none	350	none	......
Craig	1,115	....	2	.....	all	none	......
Dewey	1,513	200	none	none	25	none	......
Garfield	2,100	5,000	none	7 conc. & asp.	all	none	......
Grady	2,200	175	none	none	.....	.....	......
Hughes	1,480	148	none	none	148	none	......
Kingfisher	1,845	228	1 conc.	16 sand clay	.....	.....	side ditchces -1-5 ft.
Latimer	300	75	5 gravel	.....	.....	none	culverts
Leflore	1,500	200	5 gravel	.....	.....	none	culverts
Major	271	214	none	64	51	none	......
Oklahoma	700	300	3	150	very few	.....	culv. where needed
Pottawatomie	1,700	210	none	none	none	none	none
Oregon:							
Lake	1,300	500	16 crushed rock & gravel	200 gravel	80	350	metal culverts
Marion	1,250	900	700	40 asp. conc.	900	.....	cross drains of conc. & wood
Morrow	1,000	79	33	none	79	cross culverts	ditch & culvert, iron & conc.
Multnomah	500	500	250	100	.....	.....	......
Polk	300	200	200	16-20 hard surface	.....	.....	......
Sherman	550	250	5½	none	all	none	cross drns. & culverts
Wheeler	310	50	8	20	50	none	......
Yamhill	....	....	250	14 conc., 11 bit.	none	10	tile

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Pennsylvania:							
Armstrong	....	....	14	8	none	.....	4 in. vit. tile
Erie	1,671	....	10-20	70 conc. & brick	.....	.....	tile underdrain-ditch, filled with gravel
Monroe	750	100	35	25	some	.....	......
Potter	500	....	12 mac.	dirt	mostly all	none	......
Warren	....	....	....	20	.....	.....	conc. tile
Rhode Island:							
Bristol	35	20	2 topeka, 3 tarvia	20	15	5	storm sewers & open throat
Providence	75	all	all gravel	none	all	none	......
South Carolina:							
Greenwood	2,200	260	none	117	40	20	4-6 in. farm tile
South Dakota:							
Clay	198	70	....	.....	15	.....	......
Codington	1,280	626	15 gravel	none	90	none	......
Corson	3,200	150	none	none	150	none	......
Custer	600	45	2 crush. rk.	.....	.....	.....	metal culverts
Davison	864	200	10 gravel	none	.....	few places tiled	......
Day	1,500	150	8 gravel	none	300	none	none
Gregory	225	200	1 gravel	5 clay on sand	50	none	......
Haakon	500	200	none	none	.....	none	......
Hanson	856	10 grade	none	none	none	various places on private ditches	tile
Jackson	500	200	none	none	none	none	none
Lincoln	1,600	200	20	none	.....	5	tile drns. cem. tiles
McCook	1,200	200	10	none	15	none	.....
Miner	1,100	150	11½	none	140	none	......
Minnehaha	1,500	65	65 gravel	none	none	none	......
Perkins	500	158	none	.....	none	none	culverts
Spink	3,200	half	none	none	not much	none	none
Stanley	440	200	none	none	.....	none	......
Tripp	3,500	500	none	none	.....	.....	......
Union	250	none	none	none	none	none	......
Walworth	870	275	none	none	none	none	open ditches
Yankton	210	46	none	none	22	4	4 in. tile
Tennessee:							
Bedford, Coffee and Moore	600	150	50	none	none	none	......
Benton	209	40	none	none	40	none	......
Coche	800	25	115	none	50	140	metal & conc. culvts.
Greene	1,500	437	256	none	none	none	......
Hamilton	900	900	600	100	all	none	......
Lewis	80	45	8	.....	.....	.....	metal & conc. culvts.
Lincoln	....	....	120	.....	.....	.....	......
McMinn	600	200	40 mac.	.....	.....	.....	......
Monroe	300	190	75	none	none	.....	......
Tipton & Lauderdale	1,100	all	none	none	30%	none	......
Texas:							
Aransas	125	100	sand clay	none	none	none	little required
Bosque	1,500	800	30 gravel	none	800	none	none
Callahan	800	100	50	none	.....	.....	conc. culverts, corr. & vit. pipe
Cameron	....	50	5	2 conc.	20	none	......
Carson	250	half	none	none	all that are graded	none	......
Colorado	821	400	100	none	50	none	......
Dickins	256.3	138.5	54.5 gravel	14 sand clay	all	none	......
Edwards	190	none	none	none	none	none	none
Fort Bend	500	200	18	none	31	none	......
Gonzales	700	70%	70	none	all	.....	open ditches
Harris	1,500	1,500	350	.....	200	none	......
Johnson	600	300	10	none	.....	none	none
Limestone	900	90	5	none	none	none	......
Madison	300	50	....	.....	20	.....	......
Milam	900	750	254	none	none	none	none
Montague	2,000	120	56	none	175	none	......
Robertson	500	300	210	none	drainage with ditches on grade	none	......
Rockwall	800	100	2	none	.....	.....	......
San Augustine	250	70	12	none	none	none	......
Shackelford	350	100	16	none	30	none	......
Tarrant	1,200	500	400	130	.....	.....	......
Trinity	200-250	150	none	.....	none	none	......
White	300	150	70	none	all	none	natural
Wise	400	144	55	10	107	none	......
Vermont:							
Bennington	779	300	6 mac., 200 gravel	7	10	5	"V" shaped filled with loose stone
Orange	1,406	200	200	5	all drained	.....	loose jointed pipe in ditch filled with gravel & brok. stone
Windham	1,466	100	95% gravel	5 mac.	none	20	stone drains
Virginia:							
Augusta	1,200	350	190	.....	.....	.....	......
Brunswick	300	200	none	200 soil	none	none	......
Campbell	200	68	22 mac., 45 soil	1 conc.	all	68	V. C. pipe, corr. iron pipe, conc. culvert
Fairfax	1,000	100	72	8 conc.	all	none	......
Nansemond	125	100	30	5	25	none	......
Scott	200	200	45	.....	.....	200	cast iron pipe, corrugated metal & clay
Washington:							
Adams	1,978	235	282	none	235	none	......
Benton	2,100	1,500	200	none	20	none	none
Clallam	600	....	gravel	.....	all	none	......
Clarke	2,250	400	250	50 hard surface, 23 conc., 27 bit.	25	½	shallow side ditches & frequent pipe culvrts.
Grant	2,600	800	400	0.1 conc.	.....	.....	......
Island	300	180	150	none	50	4	4-6 in. tile

ROADS UNIMPROVED, IMPROVED, AND DRAINED—(Continued)

County and State ...	Total miles of public roads	Miles graded	Macadam or gravel	Other kinds of improved surface	—Miles drained by— Deep side ditches	Underground drains	Kind of drainage
Washington (continued):							
Jefferson	200	50	150	none	none	5	6 in. tile, porous
Lincoln	3,100	300	210	none	.....	none	......
Okanegan	1,700	1,200	120	none	.....	practically all	corrugated steel reinf. conc. pipe
Snohomish	1,000	730	600	130 conc.	130	.....	......
Wahkiakum	110	50	50	none	nearly all	none	culverts on hwy. & armco galvanized
West Virginia:							
Boone	94	12	none	none	none	none	stone & conc. culvts.
Brooke	180	45	10	14	90	.....	......
Cabell	....	....	....	50 brick	.....	.....	......
Calhoun	616	4½	none	none	.....	.....	......
Hardy	700	150	5	none	300	.....	......
Mercer	432	118	60	none	none	118	70% V. C. pipe. 30% galvanized
Mineral	700	25	5 gravel	4 conc. 12 bit. mac.	.....	96	corrugated iron. conc. vit. pipe, wood
Morgan	350	70	2	1½	70	none	......
Nicholas	600	24	none	none	124	none	......
Ohio	200	200	100	50	200	50	4 in. farm or vit tile in ditch under gravel. stone, etc.
Pocahontas	600	20	15	none	18	.....	vit. clay, galv. & cast iron
Randolph	1.500	50	12	5 conc.	1,500	none	none
Summers	500	43	1.9 mac.	8 brick, & conc.	.....	.....	side ditches 8 in. below subgrade 5 ft. out
Taylor	50	....	....	3½ brick	.....	none	not much
Wayne	94	46	½ slag	10 brick	94	all improved & parts of others	conc., V.C.P. & cor. met. culvs.
Webster	101	20	none	none	20	none	dry rubble masonry
Wetzel	1,220	562	1¼ mac.	13 conc. & brick	.....	.....	......
Wisconsin:							
Adams	1.120	100	4	40	not deep	none	......
Bayfield	....	214	150	3 crushed rock	2	none	......
Calumet	637	....	450	5	.....	....	......
Dunn	2 000	1.300	20	15 clay	5	none	......
Forest	375	198 7	....	.....	6	1	vit. tile
Grant	2.000	150	75	2	200	.....	......
Iron	124	100	17½ gravel	3 iron ore. 3½ sand clay	none	none	......
Jefferson	1.400	150	150	3 conc.	.....	1	6-in. tile
Juneau	1.235	250	1 gravel. 35 mac.	35 clay	250	2	tile
La Crosse	360	260	15 bit.	185 mac.	none	none	......
La Fayette	1.200	125	40	none	none	2	8-in. tile
Lincoln	850	600	250.	none	600	none	......
Natrona	900	400	4½ gravel. 5½ conc.	1 bit.	.....	.....	......
Portage	250	150	40	75	150	1	rock drains
Riverside	1,509 9	43.7 mac.	105 gravel	1,254 9 dirt	none	none	shallow gutters
Sauk	....	266	242	6 cem.	.....	4	6-in. tile
Trumpealeau	1,250	350	150	10	5	4	tile drains
Vernon	1 630	300	10	20	.....	.....	......
Waushara	250	100	50	30 mac.	10	5	tile & storm cross drains
Wyoming:							
Weston	400	100	none	none	all	none	......

(*Continued from Page* 327)

One of the most important matters connected with road improvement is that of drainage, but very few states or counties have even approximated the amount of this kind of work that is desirable. In the latest report of the committee of highway experts appointed to determine general specifications for an "ideal section" of the Lincoln highway, it is stated that the committee with surpising unanimity declared "that the dangerous open ditch, at present found along the greater proportion of our country roads, shall go. The ideal section will be drained by catch basins and submerged tile under the earth shoulders." Of the several hundred counties reporting on the matter of deep side ditches, we find 76 per cent reporting such ditches. Some of these report both deep side ditches and the use of underground drains, about 34 per cent of the counties reporting the greater or less mileage provided with underground drainage, although 66 per cent report no use whatever of this method of draining out the road bed. There are, of course, considerable areas and possibly whole counties where little if any subsurface drainage is necessary, but anyone familiar with highway work throughout the country knows that on a considerable percentage of even the improved highways sufficient attention has not been paid to the subject of keeping the sub-grades dry. The last column tells briefly some of the methods, kinds and sizes of pipes, etc., used in draining roads.

These include double-strength vitrified pipe, vitrified clay pipe, land drainage tile, wooden boxes; "4-inch and 6-inch farm tile laid 3 feet to 4 feet deep on one side of the road"; gravel drains; French drains; "5-inch to 24-inch clay and concrete tile drains; catch-basins and sewer pipe"; 4 to 6-inch pipe laid 30 inches deep in stone-filled trench. Perhaps the majority report tile drains 4 to 8 inches diameter. For culverts various materials were reported, including concrete, rubble, tile, cast iron, corrugated, "armco," steel, galvanized and wood.

South Carolina Highway Department

Procedures adopted for making surveys and plans and for maintaining roads. General features of design.

Stimulated by the general country-wide enthusiasm for better highways and influenced in some cases by the requirements necessary for securing federal aid, practically all of the states now have state highway commissions. Several of these are entirely new features of the state government, while many others have been modified by adopting plans of organization and details of executive and administrative features that have been found desirable by experience of other states.

One of the recently changed highway commissions is that of South Carolina, which although created in 1916, was modified by an act approved March 10, 1920. The commission, shortly after that, appointed Charles H. Moorefield as its state highway engineer, his services beginning on July 1 of last year.

To comply with the state law and to insure the most effective development of state highways, it was necessary first to lay out a system of connecting highways throughout the state and to make surveys and plans for such work as was contemplated for immediate construction. This was done expeditiously and by December 31 contracts had been completed on 25 miles of hard-surface roads and 335.6 miles of gravel, top soil and sand-clay roads. In addition the bridge division had prepared plans for 53 bridge structures, of which 11 were completed during the year totaling 619 feet of reinforced concrete and 306 feet of timber. Contracts had also been let for 2,056 feet of concrete and steel bridges, 958 feet of reinforced concrete and 565 feet of creosoted timber.

SURVEYS AND PLANS

Every survey involved consideration of the probable future development of adjacent lands; type of surfacing to be used immediately and probable future type; surface drainage and subdrainage; connections with other roads; adjusting grades to existing bridges, railroad tracks, water mains, sewers, etc.; elimination of railroad crossings; avoidance of dangerous curves and excessive grades. In every feature, cost of construction was, of course, given serious consideration.

After making preliminary location, the actual staking out is begun. Stakes are set at each 100 feet and also at humps or noticeable depressions, on the banks of ditches and streams, etc. Curves in alignment are calculated and staked out. The position of property lines, nearby houses, railroad tracks, fences, canals, streams, telephone and telegraph poles, woods, etc., are noted and measurements taken so they can be shown on the plans. A sufficient number of stakes are referenced so that they can be replaced if disturbed.

Following this, levels are run and the right-of-way cross-sectioned for at least 25 feet on either side of the road limits. Following this a system of check levels is run, generally by an independent line of bench levels, and if discrepancies are found it may be necessary to run a third line of levels.

Each survey party is usually composed of three men employed by the state department and two furnished by the county. The chief of the party studies the route, selects the location, sees that the party sets the stakes at proper points, checks the calculations and notes made by the instrument men, makes recommendations as to proper sizes and location of culverts and bridges, makes a daily report to the office of the department, and arranges for board, lodging and transportation for the party. In difficult situations or in case of protest by property owners, he calls upon the chief of survey, and if the latter cannot adjust matters in the field he takes them up with the state highway engineer.

During 1920 the state department had from one to six survey parties operating. These parties surveyed a total of 370 miles of road in 20 counties at an average cost of $92.77 per mile. In addition, the completed plans, not including bridge plans, cost $61.30; making a total average cost of $154.07 per mile for surveys and plans.

The plans were prepared by the drafting division. For each road there was prepared plan-profile sheets and cross-section sheets, and detail sheets of all bridges and culverts except pipe culverts. Each sheet of plan and profile shows 3,000 feet of road. The plan is placed at the top of the sheet and shows all curves with their length and degree, the position of bridges, culverts, fences and other physical features, the name of property owners and their property lines, and the location of the old road and branch roads. The profile shows the elevation of the ground at each stake, elevation of bottoms of streams and ditches, sizes and elevation of culverts and bridges, both those to be left in place and those to be installed, the elevation of highest known water so far as this could be ascertained, and the grade elevation proposed for the finished road.

The cross-section shows the present ground surface at right angles to the survey at each stake and the outline of the proposed cut or fill. The area of the cut or fill is calculated and used for computing the volume of grading necessary.

The best record made by a draftsmen of the department forces in turning out completed plans was about 34 hours per mile of finished plan, this not including plans for bridges or culverts. There were several changes in the drafting room force but that employed during the year was equivalent to 16.2 men employed for the full year.

MAINTENANCE

The state had under maintenance during the year 411 miles of road, of which 6.9 miles was asphalt concrete, 4.0 bituminous macadam, 15.1 cement concrete, 4.4 gravel, 70.7 sand-clay, 309.2 top soil, 1 waterbound macadam. Part of these were maintained by the gang system and part by

patrol, 11 counties by the latter as against 31 by the former. $66,519 were spent, giving an average maintenance cost of $161.71 per mile.

The floating gangs were equipped with motor trucks, road machines, drags, etc., and were used either on unusually long roads or on several roads. The patrol organizations generally consisted of patrolmen who lived along the road on which they worked and who were equipped with a small road machine or road drag, small tools, etc., but furnished their own team and wagon. It is expected that the patrol system will gradually be extended over a large proportion of the roads under state maintenance. The funds received for state maintenance consist of 80 per cent of the motor vehicle licenses received from the several counties.

ROAD DESIGN

The department has not adopted inflexible rules for designing and constructing state roads, but endeavors to adapt each project to local conditions so as to get maximum value for funds expended. In general it aims to adopt road locations that will not need to be changed in the future under any traffic developments; to avoid and eliminate railroad crossings; afford adequate accommodations to traffic with respect to grades, width of roadway, sharpness of curbs, etc.; and secure the greatest practicable durability by effective drainage, possibility of proper maintenance and sufficient width of right-of-way.

In general, it has made the right-of-way not less than 50 feet wide; the minimum width of roadway 28 feet on embankment and 32 feet in cut; a minimum of 16 feet width of hard surfacing with 18 feet ordinarily; a limiting grade of 5 per cent for lengths of more than 600 feet and 6 per cent when the length is less than 600 feet and the view is open; minimum grade for side-ditches one-half of 1 per cent; maximum curvature of 12 per cent in rolling country, and in hilly and mountainous country such that a clear view ahead can be had for at least 150 feet, with curves sharper than 6 per cent banked and widened where hard surface is used. Surfacing is made 12 inches thick at the center and 4 inches at the edges for top soil; 10 inches at the center and 4 at the edges for sand-clay; 8 at the center and 6 at the edges for concrete; 6-inch concrete foundation for asphalt surface, 8 inches thickness for stone base, and 2 inches thickness of asphaltic concrete surfacing. In designing ditches and culverts in hilly country it is assumed that a 15-inch pipe will drain 3 acres, an 18-inch pipe 5 acres, a 24-inch pipe 8 to 10 acres, a 30-inch pipe 10 to 15 acres, and a 36-inch pipe 15 to 30 acres. In rolling and flat country larger areas can be drained.

Bridges are required to be designed so as to carry 2 to 15-ton trucks, have a width of roadway of 18 feet, and be built of either concrete, steel or creosoted timber, with a strong preference for the first. The unit strengths assumed are: for concrete, 650 pounds per square inch in compression; steel, 1,600 pounds per square inch in tension or compression, with the customary corrections for compression in long columns; creosoted yellow pine, 1,350 pounds per square inch; loblolly, 1,200 pounds per square inch.

State Work in 1920 and 1921

Figures giving the amount of highway work done in the several states last year and contemplated for this year, together with the money available for the latter. Also mileage of improved and unimproved roads in the several states.

Within the past few weeks we have received from highway officials of the several states replies to a questionnaire which we sent them asking: "Amount of each kind of pavement, number of bridges and other highway work completed by state forces or under state supervision in 1920." "Amount of such work contemplated in 1921." "Money available for state expenditure on highways in 1921." "Miles of improved and of unimproved roads in your state." "Changes made, for this year's work, in the specifications for road work that were in force in 1920." The data are tabulated on the following page.

These replies show that, in spite of the unfavorable conditions of last year, most of the states did quite a little amount of road work. However, the majority of them expect to do considerable more this year than they did last. As to the amounts available, these are seen to range, for individual states, from $1,400,000 to $60,000,000, totaling about $600,000,000. It is, of course, understood that these sums, while available, will in few cases be entirely expended this year; in fact, in many cases the sum mentioned is the total available for two years or more to come.

Many of the state officials did not pretend to have figures for the mileage of improved and unimproved roads. In such cases the figures given by us are those published by the Bureau of Public Roads and are presumably as nearly correct as it is possible to estimate them. These show about 10½ per cent of all the roads in the states classed as improved.

Not many of the states have made any radical changes in their specifications, but a few have done so. A discussion of these will be given in a later issue, there being insufficient space available this week for that purpose.

State	Amount of highway work done by State in 1920	Amount of such work contemplated in 1921	Money available for 1921	Miles of improved roads in state	Miles of unimproved roads in state
Alabama	19.54 asphalt, 29.03 gravel and chert, 86.45 sand clay, 3.19 grading. Concrete bridge. Total cost, $1,623,466.57.	4.71 asphalt, 183.8 gravel, 67.59 sand-clay, 65.1 bit. mac.	$4,000,000 to 5,000,000	5,800	52,200
Arizona*	....	....	8,000,000	475	11,600
Arkansas	$397,500 earth, $7,050,000 gravel, $1,500,000 mac., $1,536,000 penetration mac., $2,767,500 asphaltic conc., $2,160,000 conc., $1,410,000 bridges—total cost, $16,803 000.	$400,000 earth, $9,000,000 gravel, $2,000,000 mac., $2,000,000 penetration mac., $3,600,000 asphaltic concrete, $2,880,000 concrete, $1,880,000 bridges; total cost, $21,760.00.	21,760,000	5,200	46,800
California*	31 Topeka on conc., 437 conc., 34 oiled mac., 1 bit. conc., 280 grading (a).	....	26,000,000	13,000	48,039
Colorado	20 concrete, 46 gravel, 54 grading	28 conc., 100 gravel, 57 grading.	3,400,000	....	....
Connecticut	1.93 grading, 16.89 gravel, 13.57 mac., 6.28 bit. mac., .28 bit. conc., 3.74 conc., $94,330; bridges.	..nished work left.	8,000,000*	1,557	12,443
Delaware	11 penetration mac., 48 cement concrete.	56 uncompleted contracts, 40 mi. expected to be let.	3,849,674	326	3,470
Florida*	....	....	7,725,000	3,900	14,095
Georgia	52.0 paved, 93.9 sand-clay, 8.2 graded (c)	212 paved, 840 sand-clay, 47 grading (b).	10,000,000*	13,200*	67,469*
Idaho	40 paved highways, 380 rocked & graveled rd., 300 earth, 7 bridges (a).	....	6,000,000b	1,400	23,600
Illinois	341 hard surf. rds., 56.77 grading, 30 bridges.	190 hard surfaced roads, 78 18 grading & 51 bridges to be completed from 1920 work.	8,865,517	9,910	85,090
Indiana	6 04 bit. concrete, 12.696 concrete pavement, 2.44 reinforced conc., 2.66 2-course conc., 2.39 brick, 13 bridges—total cost, $1,032,183.26.	125 road and bridges plus 100 mi. now under contract.	5,000,000	35,000	60,000
Iowa	46.6 paving, 105.5 gravel, 309.8 grading.	203 paving, 456 gravel, 1,860 grading.	30,000,000	1,880	101,820*
Kansas	16.5 brick, 35.6 conc. 13.3 mac., 26.3 gravel, 23.8 earth.	38.2 brick, 94.8 conc., 24.8 mac., 45.0 gravel, 55.6 earth.	20,000,000*	1,640*	109,320*
Kentucky	101.2 earth, 52.1 gravel, 110.6 mac., 1.4 bit. mac., 13.4 rock asphalt, 6.7 concrete, 2.0 brick, 1.5 cinder, 100.1 surface treatment.	10 conc., 60 bit. or rock asphalt, 50 mac., 25 gravel, 75 earth, 50 other types.	7,000,000	14,490*	43,438*
Louisiana*	....	....	6,000,000*	2,700*	21,863*
Maine	180 gravel, 18 bit. macadam.	235 gravel, 60 bit. mac., 60 conc.	5,000,000	3,525*	20,012*
Maryland	86.45 conc., 2.60 sheet asphalt, 19.48 sheet asphalt on mac. base, 6.50 mac., 19.38 gravel.	28 left from 1920.	7,600,000	3,235*	13,090*
Massachusetts*	....	....	8,000,000	9,100	9 581
Michigan	204.23 gravel, 25.7 mac., 9.0 bit. mac., 9.5 b[illegible]rface, 10.7 conc., 8.8 bit. conc., 0.7 sheet asphalt, 0.4 brick.	....	35,000,000	10,870*	63,050*
Minnesota	59 concrete, 19 asphalt concrete.	About 100 miles.	25,000,000	7,080*	79,280*
Mississippi	42.1 earth, 2.8 conc., 142.1 gravel.	....	5,000,000	2,850*	42,700*
Missouri	415.7 earth grading, 145.2 gravel, 27.7 mac., 5.6 chert, 2.0 chats, 7.2 bit. mac., 2.7 warrenite (a).	95 bit. mac., 958 gravel, 54 mac., 47 brick, 108 conc. (b).	8,370,000	7,740*	88,100*
Montana	19.8 conc., 197.3 gravel, 75.3 grading.	41 conc., 1.4 bit., 555 gravel, 177.7 grading, 10 bridges.	5,200,000	500	59,500
Nebraska	6 1-2 brick, 8 conc., 55 sand clay, 23 gravel, 1.215 earth grading, $200,000 bridges.	50 paving, 60 gravel, 1,200 earth grading, $200,000 bridges, $300,000 culverts.	6,000,000	1,550*	80,000
Nevada	13.8 conc., 64.3 gravel, 89.0 graded, 6 bridges.	....	1,380,000	200	1,900
New Hampshire	48.11 gravel, 12.40 crushed gravel, .52 earth, 6.41 grading, 1.05 bit. macadam, 2.51 mac., 4.93 asp.	....	2,500,000	1,500	13,500
New Jersey	98 miles.	69 miles.	16,000,000	6,050	8 767
New Mexico	109.4 gravel, 43.1 crushed stone, 24.1 grading, 18.9 concrete, 22.0 caliche (a).	....	4,000,000	1,960	47,607
New York	84.3 concrete, 64.9 bit. macadam, 23.5 macadam, 3.9 gravel.	At least 500 mi. hoped for.	48 000,000	12,330	67,670
North Carolina	....	$6 000,000	10,000,000	6 000	46,000
North Dakota	524 earth, 43 gravel.	835 miles	3,000 000	3,500	66,500
Ohio	36.2 brick, 12.9 bit. concr., 71 8 bit. mac., 35.0 pl. concr., 46 2 rein.-conc., 69.5 mac., 20.4 mac. surface treated.	6.6 bitoslag, 8.7 bitulithic .136.5 brick, 17.4 bit. conc., 121.0 bit. mac., 163.6 conc., 58.3 grading, 24.3 gravel, 23.7 Kentucky rock, 144.5 mac., 8.5 sheet asphalt.	12,442,000	31,800*	54,554*
Oklahoma*	....	....	8,000,000	700	107,216
Oregon	16.4 conc., 167.7 bit. conc., 275.0 mac., 474.8 grading, 107 bridges.		24,900,000b	5,000*	31,819*
Pennsylvania	325.6 reinf.-conc., 1.1 plain conc., 58.5 bit. top on conc. base, 17.4 brick, 1.9 sheet asp., 9.3 mac.	807 miles total.	35,000,000b	4,500	85,500
Rhode Island	2 mac., 12.9 bit. mac., 10.2 bit. con., 1 conc., 0.5 sheet asphalt, 10 bridges.	7 1 mi. bit mac., 19.2 bit. conc., 1 3 concrete, 12 bridges.	1,400,000	1 250	1,125
South Carolina	25.1 hard surface, 335.6 gravel, top soil, sand-clay.	11.6 hard surface, 275.7 gravel, top soil, sand-clay (d).	6,000,000*	3,800*	38,426*
South Dakota	....	....	8,469,380	800	95,506
Tennessee	17.9 chert, 7.0 conc., 43.5 mac., 24.6 bit. mac., 5.8 rock asp., 36.2 grading	....	7,500,000	8,800*	37,250*
Texas	7.1 conc. pavement, 173.94 gravel, crushed stone w. bit. topping, 516.06 gravel or crushed stone, 169.93 sand clay or shell, 109.56 grading & conc. drainage structure, 5 bridges (a).	148.1 conc. pavement, 714.3 gravel or crushed stone w. bit. topping, 1,740.1 crushed stone or gravel, 149.2 sand-clay or shell, 344.1 grading & conc. drainage structures, 18 bridges.	60,000,000*	1 000	147,000
Utah*	....	....	6,000,000	1,650	7,160
Vermont*	....	....	2,000,000	2,300	11,949
Virginia*	....	....	10,000,000	6,150	47,238
Washington	163.8 crushed rock & gravel, 53.4 conc., 2.0 asp. mac., 1.7 warrenite.	....	14,000,000*	1,945	44,850*
West Virginia	....	....	6,000,000	1,600*	30,424*
Wisconsin	623 earth, 624 gravel, 126 top soil, 88 concrete.	245 concrete and others.	27,514,487	15,500*	61,780*
Wyoming	[illegible].0 conc., 1.1 bit., 80 gravel, 7[illegible] earth.	4 3 conc., 100 gravel, 300 earth.	3,000,000*	600*	14,197*

(a)—Includes 1919 and 1920. (b)—Includes 1921 and 1922. (c)—Total completed to date. (d)—Under contract.
* Information not furnished by state officials but derived from o[illegible]ces.

NEWS OF THE SOCIETIES

April 18-23 — UNITED STATES GOOD ROADS ASSOCIATION. Greensboro, N. C.

Apr. 19 — CLEVELAND SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

April 21—CINCINNATI SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting with Engineers' Club of Cincinnati.

April 21-22—BANKHEAD NATIONAL HIGHWAY ASSOCIATION. 5th annual convention. Greensboro, N. C. Secretary, J. A. Routree, Birmingham, Ala.

April 22 — METROPOLITAN SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting with American Institute of Electrical Engineers.

April 22—BIRMINGHAM SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting with Atlanta, Birmingham and New Orleans sections, with members of Council present. Battle House, Mobile, Ala.

Apr. 25—CHICAGO SECT., AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Joint meeting with ELECTRICAL AND MINING SECTIONS, WESTERN SOCIETY OF ENGINEERS and ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS.

April 27—AMERICAN SOCIETY OF CIVIL ENGINEERS. Annual convention. Houston, Texas.

Apr. 27-29—BUILDING OFFICIALS CONFERENCE. Cleveland, Ohio.

Apr. 27-29—SOCIETY OF INDUSTRIAL ENGINEERS. Milwaukee, Wis.

April 27-29—UNITED STATES CHAMBER OF COMMERCE. 9th annual meeting. Atlantic City, N. J.

April 27-29 — BUILDING OFFICIAL'S CONFERENCE. Seventh annual meeting. Cleveland, Ohio.

April 28-29—MID-CONTINENT SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting of Chemical Eng. Societies. City Auditorium or Convention Hall, Tulsa, Okla.

April 29 — EASTERN NEW YORK SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Edison Club Hall, Schenectady.

April 29 — COLORADO SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Metropole Hotel.

Apr. 29—SAN FRANCISCO SECTION AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

May 2-4—MISSISSIPPI VALLEY ASSOCIATION. 3d annual convention. New Orleans, La.

May 4-7 — NATIONAL FOREIGN TRADE CONVENTION. 8th convention. Cleveland, Ohio.

May 6 — VANCOUVER SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

May 9 — HARTFORD BRANCH AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Get-together dinner at City Club.

May 9-11—AMERICAN ASSOCIATION OF ENGINEERS. 7th annual convention. Buffalo.

May 9-12—SOUTHWEST WATER WORKS ASSOCIATION. Shirvin Hotel Headquarters, Oklahoma City, Okla.

May 10-12 — CANADIAN GOOD ROADS ASSOCIATION. 8th Annual convention. Halifax, Can. Secretary George A. McNamee, Montreal.

May 17—CLEVELAND SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. Annual dinner.

May 17-19—NATIONAL FIREMEN'S ASSOCIATION. Twenty-third annual convention. Fort Wayne, Ind.

May 19 — SAN FRANCISCO SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

May 20 — AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS. 370th meeting. Engineering Societies Building, New York City.

May 20 — PHILADELPHIA SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Annual dinner, Hotel Adelphia Roof.

May 21 — ATLANTA SECTION, AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Joint meeting with ATLANTA SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

May 23-26 — AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Spring meeting. Congress Hotel, Chicago.

AMERICAN ASSOCIATION OF ENGINEERS

The seventh annual convention of the American Association of Engineers will be held in Buffalo May 9 to 11. New officers for the ensuing year will be elected.

Educational work of engineers within the organization to establish closer contact with the management and to prepare men for high executive positions was begun at a meeting held on March 24 in an Illinois Central office building, Chicago. Mr. C. C. Haire, presided. The Illinois Central section of the American Association of Engineers consists of 125 railroad professional engineers.

The Washington office of the American Association of Engineers, A. T. Koehler, district secretary, has been moved to Chesley building, 1317 New York avenue, N. W., Washington, D. C.

The Detroit Chapter in co-operation with the Detroit Board of Commerce has arranged for a lecture by Hon. Harry M. Fisher, judge of the Municipal Court of Chicago, at the Board of Commerce auditorium in Detroit on March 26.

Judge Fisher went abroad as chairman of the Ukraine Commission for the Joint Distribution Committee of America for Jewish sufferers. His lecture in Detroit will be based on his observations and findings in that country and will be entitled "The Truth About Soviet Russia."

THE FEDERATED AMERICAN ENGINEERING SOCIETIES

Gratifying progress is being made by the Federated American Engineering Societies. Permanent offices have been set up, the work of organization is developing rapidly, and there has been much constructive activity in legislation. A statement by the executive secretary, L. W. Wallace, says:

Permanent headquarters of the Federated American Engineering Societies have been established in Washington on the third floor of 719 Fifteenth street, N. W. (National Savings & Trust building). Sufficient space has been obtained to provide a large lounging room or conference room for those who may desire to use the headquarters as a meeting place. It will be the purpose of the headquarters at all times to render as much personal service as possible to engineers who visit Washington.

A special plan will be developed to the end that engineers visiting Washington may be able to transact business with the minimum amount of effort on their part. Engineers, therefore, are asked to notify it of an intended visit to Washington so that arrangements may be made to care for them. The executive secretary will be permanently located in Washington in the near future.

There is great activity in a number of states regarding the licensing of engineers. The F. A. E. S. has in every instance taken a part in such legislation. It has made an effort to have a representative at every meeting. It is not the desire of the F. A. E. S. to initiate such legislation nor to urge its passage, but it does take the position that it desires to be instrumental so far as possible towards securing the passage of a bill that will not be detrimental to public interests and to the engineering profession.

The Patents Committee has considered a congressional bill that will provide more adequately for the Bureau of Patents. It has sent out a request that influence be brought to bear upon Congress for the establishment of better support for the Bureau of Patents. Member-societies and others have responded with a fine spirit of cooperation.

A careful study is being made by the Employment Service to determine what policies should be adopted that will enhance the value and usefulness of the service to the individual members of the member-societies. This report will be submitted to the executive board at its meeting on April 16.

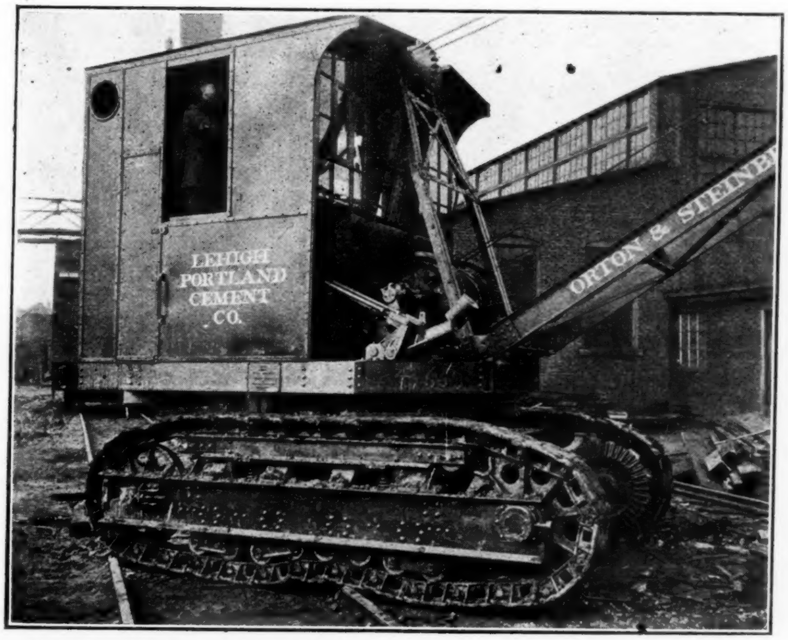
The work of the Committee on Elimination of Waste in Industry is progressing according to schedule. The field work will be completed on or before April 15. The final report will be published in June. The findings of the committee thus far are very significant and it has every reason to believe that the publication of this report will create a great deal of interest.

There is a large interest on the part of engineering societies that have not yet become affiliated with the F. A. E. S. In recent weeks two have joined, namely, The Boston Society of Civil Engineers and the Engineering Society of Milwaukee. There are a number of other societies that are either voting upon it at the present time or have it under consideration by the executive boards. It is reasonably sure that a number of other societies will become affiliated with the A. F. E. S. before July 1, at which time the opportunity of coming in as a charter member will expire.

The last meeting of the executive board was held in Philadelphia on April 16. The executive board were the guests of the Philadelphia Engineering Club and the sessions were held at the Engineers' Club. The club made preparations for a large attendance which duly materialized. There was a dinner at the Bellevue-Stratford on the evening of April 16 which was addressed by the president, Mr. Hoover.

New Appliances

Describing New Machinery, Apparatus, Materials and Methods and Recent Interesting Installations



CRAWLING TREAD LOCOMOTIVE CRANE DEVELOPED FROM MILITARY TANK TYPE OF TRACTION

A NEW CRAWLING TREAD CRANE

One of the latest crawling tread cranes developed is the OS Dependable, manufactured and sold by the Orton & Steinbrenner Co. Two sizes are made, both especially adapted to contractor's use; they are rated as 7 tons and 12 tons capacity.

The crawling tread is an improved form of that used on government tanks during the European war. The tread links and sprockets are of cast steel and the chain idler rollers are bronze bushed with patented pressure system of lubrication. Each crawling tread is supported on bottom between drive sprocket and idler by four pairs of idler rollers. Each pair is carried in and equalizing strut backed by heavy coil spring and when traveling over obstacles will tilt as much as 6 inches from the horizontal. It will travel up grades of 20 to 30 per cent in soft material.

Tread link ends overlap and no foreign material can enter the spaces between, thereby eliminating the principal difficulty experienced heretofore in machines of this type. Surface area of crawling tread is great enough to reduce unit pressure on ground to 10 pounds per square inch, although crane weighs in the neighborhood of 4,500 pounds.

The sprocket is driven by steel bevel gears and no chain drive is used. The hoisting mechanism is designed mainly with a view to accessibility and consists of four main horizontal power shafts driven through a train of cast steel cut spur gears and three auxiliary vertical shafts driven by cast steel bevel gears. Any one function may be operated independently of the others or all may act together.

For operating a bucket, double automatic drums are regularly supplied, thus doing away with one set of levers, and increasing simplicity of operation. Frictions are of large diameter and made of bronze; no wood friction blocks are used. The large braking surfaces insure quick action in lifting and releasing the loads and minimize wear. The crane can be turned completely around in a radius about equal to its own length. In addition to clam-shell or orange-peel bucket, pile driver attachments, derrick hoists and drag-line equipment can be operated.

The standard 7-ton crane is equipped with a 30-foot boom. The standard 12-ton is equipped with 35-foot boom and extra lengths may be supplied. Broad-faced road wheels or standard or special gauge rail tracks can be furnished besides crawling tread.

PIPE CUTTING MACHINES

The pipes and tubes manufactured by the Box Machine Company are illustrated on detachable pages that can be inserted in a filing cover, furnished for the purpose. They can be furnished either geared or belt driven. The number 10 cutter is mounted on a cabinet pedestal and has a capacity for cutting ⅜-inch pipe in 2 seconds and 6-inch pipe in 1 minute 43 seconds. The cutter discs are 6 inches in diameter and are provided with an oil pump and with a grinding attachment.

OVERLAND CRANES

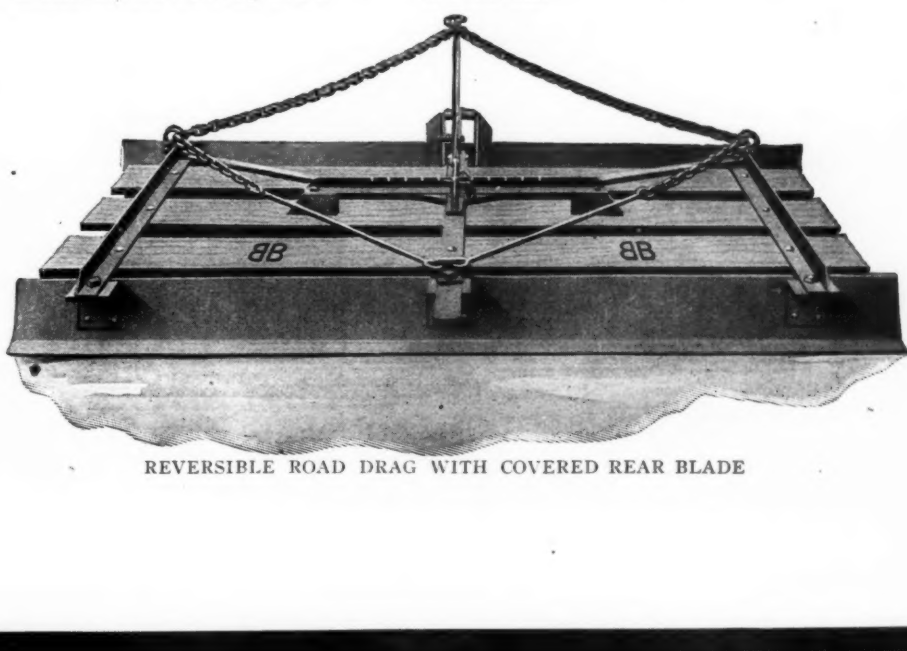
Overland cranes manufactured by the Overland Crane Company are recommended for simplicity in design, small number of parts, differential drive, accessibility, and unusual strength.

They are full-revoving ¾-yard, 5-ton capacity with a 30-foot boom and are suitable for road building, contractors' use and erection purposes.

B B REVERSIBLE ROAD DRAG

The B B reversible road drag made by the Bayne Manufacturing Company, embodies four special and important features; namely, the reversal or change of angle of the drag by means of a rear lever that controls it without danger to the operator; the maintenance of the rear troweling blade always in the trail of the front cutting blade, thus keeping the drag always at the same width; the curvature of the rear blade to form a trowel that tracks, puddles and trowels the surface to a hard, tough, smooth roadbed, and the excellent service for opening and cleaning the ditches at the roadside.

It is easily handled by one man and two horses and can be pulled straight ahead as a leveler or smoother or can be used to transfer the earth from the edge toward the center to crown the roadbed. The most important feature is the rear hitch that permits the drag to adjust itself to any reversing angle and insures the travel at the rear blade in the trail of the front one, which is particularly valuable for cleaning roadside ditches.



REVERSIBLE ROAD DRAG WITH COVERED REAR BLADE

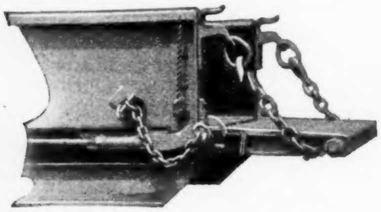
MURDOCK ANTI-FREEZING BUBBLE-FONT

The anti-freezing bubble font, manufactured by the Murdock Manufacturing & Supply Co., is designed for use in streets, parks, playgrounds, school grounds, semi-exposed and uncertainly heated enclosures and is claimed to be unfreezable, indestructable, automatically drained, anti-contagious, and non-spurting. It is self-closing; all of the inner parts are accessible or removable by removing two pedal and two top bolts. It has an adjustable lock regulating device, a protecting air jacket, and is held rigidly in place by a heavy bronze spring.

HEIL DUMPING EQUIPMENT

Dumping units manufactured by the Heil Company include a variety of steel bodies, hydro-hoists and tail gate devices that are maintained in stock suited to several styles of chassis shown in bulletin 115. They are all thoroughly tested and guaranteed and are made by modern machinery in a plant with a new 35,000 square foot addition.

The road work body is square cornered and straight sided, permitting boxes, boards, packages, blocks, tiles, bricks, etc., to be piled closely. Dumping is promoted by the fact that all bodies are made 3 inches wider at the rear than in front, thus facilitating the discharging of wet sand or concrete.

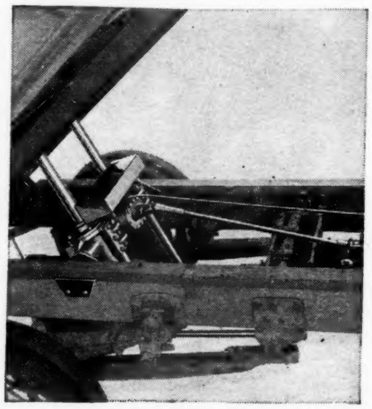


DOUBLE ACTING TAIL GATE

Bodies are fitted with single acting tail gates or with double acting tail gates, hinged at both top and bottom to enable the gate to lay down level with the floor. The tail gates are opened by a manual device having goose neck hooks attached to the body and operated by a lever easily accessible from the driver's seat.

Heavy road work bodies are supplied with a chain fender device to regulate the position of the gate and the thickness of the layer of crushed stone and spread it uniformly when dumped.

The hydro-hoist that can be used on any dump truck is mounted under the body and utilizes all the loading space back of the cab. It permits a short wheel base and is lighter than any other under-the-body hoist and eliminates all cables, pulleys and rollers. It is self-contained, with a tank communicating directly with the cylinders, and the pumps are operated to make the oil serve as a cushion. Its lifting power



HYDRO-HOIST FOR DUMP BODIES

is unlimited and it can dump with one rear wheel lower than the other.

Heil dumping equipment has been adopted by many state and county highway departments, some of which have about 200 units in operation.

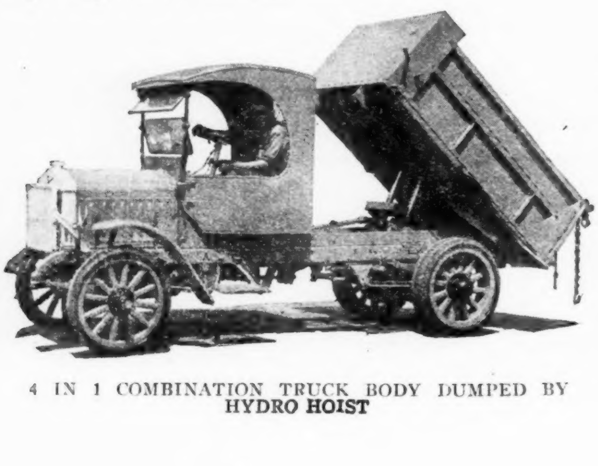
C. M. B. SERVICE BOX

The service boxes for street mains, manufactured bv the H. W. Clark Co., have a heavy cast iron base to enclose the valve that is slotted at opposite ends to engage and center a service pipe. The upper part is constructed of a heavy cast iron pipe, in which a telescopic top section moves vertically to permit displacement by frost without moving the bottom portion. The top of the telescopic pipe is closed with a screw cap and is provided with a transverse vertical pin to prevent accidental turning. It is made in 18 sizes from 1 inch to 9½ inches and with adjustments of from 1 foot to 10½ feet in length.

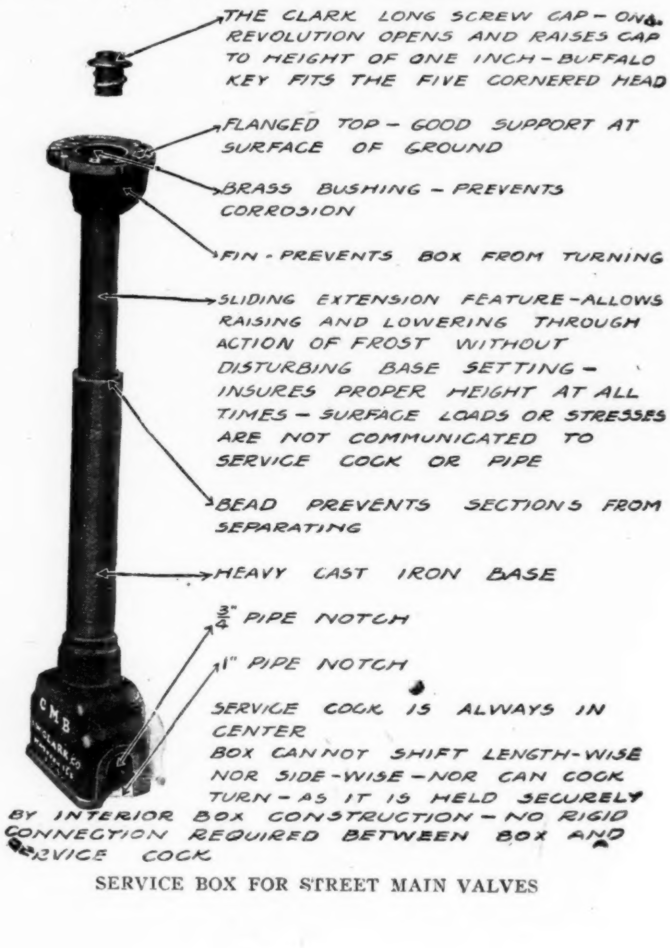
Its advantages are that it prevents the loss and breakage of bolts and tops, prevents digging up to adjust grade, prevents filling boxes with trash, prevents damage to service box or pipes caused by heavily loaded wagons and eliminates difficulty in engaging key.

TARVIA MACADAM ROADWAY

The Barrett Company has issued a booklet entitled "How a Tarvia Macadam Roadway Is Constructed" that contains useful and attractive road-building information. It illustrates and discusses the foundations, the stone quarry, the stone crusher, making the base course, rolling and filling it, placing and rolling the wearing course and covering it with hot Tarvia applied under pressure through a patent nozzle. It describes the placing and covering of the tarred surface, the application of the seal coat of Tarvia and the final coat of stone chips, finishing, rolling and maintenance and also gives information concerning the filling of joints in block pavements.



4 IN 1 COMBINATION TRUCK BODY DUMPED BY HYDRO HOIST



SERVICE BOX FOR STREET MAIN VALVES